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Contract No. DE-AC05-81OR20722

RADIOLOGICAL SURVEY OF THE ALBANY RESEARCH CENTER

Albany, Oregon

Bechtel National, Inc.
Advanced Technology Division

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RADIOLOGICAL SURVEY
OF THE
ALBANY RESEARCH CENTER
ALBANY, OREGON

JANUARY 1985

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By

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ABSTRACT

In early 1984, a radiological survey was conducted at the Albany Research Center (ARC) in Albany, Oregon. The survey was performed as part of the Formerly Utilized Sites Remedial Action Program (FUSRAP), a U.S. Department of Energy effort to identify, clean up, or otherwise control sites where low level radioactive contamination (exceeding current guidelines) remains from the early years of the Nation's atomic energy program. From 1978 through 1982, the Argonne National Laboratory (ANL) conducted radiological surveys of the ARC and identified areas with radiological readings above background. The 1984 survey was necessary to determine actual levels of contamination in each area and to define the locations and boundaries of above-guideline contamination. The survey was conducted by the FUSRAP Program Management Contractor, Bechtel National, Inc., and its radiological subcontractor, Eberline Instrument Corporation.

The 1984 survey revealed site field areas with above-guideline concentrations of thorium-232 and radium-226 in surface and subsurface soils. Using the 1984 survey findings for surface area and depths of contamination, and based on current cleanup guidelines for thorium-232 and radium-226, approximately 2000 m³ (2600 yd³) of contaminated material would require removal for the ARC site to comply with guidelines. Cleanup of approximately 5 m³ (6.5 yd³) of above-guideline contamination in two sumps, one drain, and associated piping also would be required.

In addition, nine site buildings contained scattered above-guideline contamination on floors and/or walls, in trenches and drains, and on equipment. Decontamination could be accomplished with the removal of approximately 1 m³ (1.3 yd³) of surface material, plus decontamination of drains, trenches, and equipment as appropriate.

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ABBREVIATIONS

cm	centimeter
cm ²	square centimeter
dpm/100 cm ²	disintegrations per minutes per 100 square centimeters
ft	foot
ha	hectare
l	liter
m	meter
uR/h	micro-roentgens per hour
mrads/h	millirads per hour
pCi/g	picoCuries per gram
pCi/l	picoCuries per liter
pCi/m ³	picoCuries per cubic meter
pCi/m ² /sec	picoCuries per square meter per second
yd ³	cubic yards

1.0 INTRODUCTION AND SUMMARY

This report describes the procedures, results, and significance of findings of a radiological survey conducted during February and March 1984 at the Albany Research Center (ARC) in Albany, Oregon. The survey was conducted as part of the Formerly Utilized Sites Remedial Action Program (FUSRAP). FUSRAP is a U.S. Department of Energy (DOE) program to identify, clean up, or otherwise control sites where residual radioactive contamination, at levels above current guidelines, remains from the early years of the nation's atomic energy program. Under contract to DOE, Bechtel National, Inc., (BNI) acts as the Program Management Contractor (PMC) for FUSRAP.

Earlier radiological surveys performed June 1978 through September 1982 by Argonne National Laboratory (ANL) had established that contamination existed at the site (Refs. 1 and 2). The 1984 radiological survey was necessary to define precise locations and boundaries of the contamination identified in the ANL surveys, as a prelude to possible remedial action at the site. The 1984 survey was conducted by BNI and its radiological subcontractor, Eberline Instrument Corporation (EIC).

The survey covered those site field areas which had been previously identified by ANL as exhibiting above-background readings, plus all areas within 10 m of buildings. In the field, measurements were made for near-surface gamma, beta-gamma dose rates, and gamma exposure rates. Boreholes were drilled and gamma logging was performed at 15-cm vertical intervals. These measurements were calibrated against the results of subsurface soil sample analyses. Surface soil samples and sediment samples also were collected and analyzed, as were on-site and off-site surface and subsurface water samples.

In addition to the field survey, 10 site buildings previously identified by ANL as being contaminated, plus two other

buildings identified as contaminated by A. H. Environment, Inc. (Ref. 3), were characterized during this survey. Specific areas surveyed in each building were chosen based on the results of the previous surveys. Surface areas surveyed followed a 1 m x 1 m grid on floors and walls. The floors and, when applicable, the walls in each building were monitored for surface alpha contamination and beta-gamma dose rates. When appropriate, smear samples were taken for transferable alpha and beta contamination. Floor/wall intersections, ceiling beams, ventilation systems, the openings of drains, trenches, and equipment were also surveyed as appropriate. Complete survey procedures are described in Section 3.0.

Results of the field surveys showed areas of elevated concentrations of thorium-232 and radium-226 in surface and subsurface soils. Approximately 2000 m³ (2600 yd³) of contaminated soil would require removal for the site to comply with guidelines. In addition, approximately 5 m³ (6.5 yd³) of contaminated sediments would require removal from exterior sumps and a drain opening. Associated piping found to be contaminated during the remedial action would also be removed.

The total amount of building contamination is relatively small. Surface (floors and walls) decontamination would require the removal of only approximately 1 m³ (1.3 yd³) of contaminated material. Decontamination of equipment, trenches, etc., would also require removal of material. Because some equipment will be decontaminated and other equipment will be removed, the total volume of contamination from equipment will be determined during remedial action. Complete survey results are reported in Section 4.0.

2.0 SITE DESCRIPTION

2.1 LOCATION AND DESCRIPTION

The ARC site is located in Albany, Oregon, about 37 km (23 miles) south of Salem, Oregon, as shown in Figure 2-1.

The ARC property covers an almost-rectangular area of approximately 14.4 ha (36 acres). It is bounded on the north by Queen Avenue, on the east by Liberty Street, on the south by a tennis club, and on the west by Broadway Street. The ARC site comprises three main areas: the ARC proper, which consists of a number of buildings in the northernmost 11.7 ha (29 acres) of the site; a 0.8-ha (2-acre) Biomass Research Facility (inactive), which occupies the center of the site; and a 5.7 ha (14 acre) grass-and-weed covered area known as the "Back Forty," which occupies the southernmost end of the site. A plan view of the ARC is shown in Figure 2-2. Figure 2-3 is an aerial photograph of the site and its immediate environs.

2.2 SITE HISTORY

From 1948 to 1956 the ARC was involved in operations involving melting, machining, welding, and alloying thorium. Research on uranium and thorium alloys also was conducted on-site from 1955 to 1978. During these operations, portions of the Biomass area and the Back Forty were used as waste disposal areas for materials containing thorium and uranium decay products. Placement of materials in these areas ended in 1956.

During the 1948-1978 era of the Manhattan Engineer District (MED) and U. S. Atomic Energy Commission (AEC) work at the site, process buildings and surroundings were decontaminated at various times to guidelines provided by the AEC. Decontamination guidelines which were used during those early cleanup efforts were not as specific as the guidelines in effect

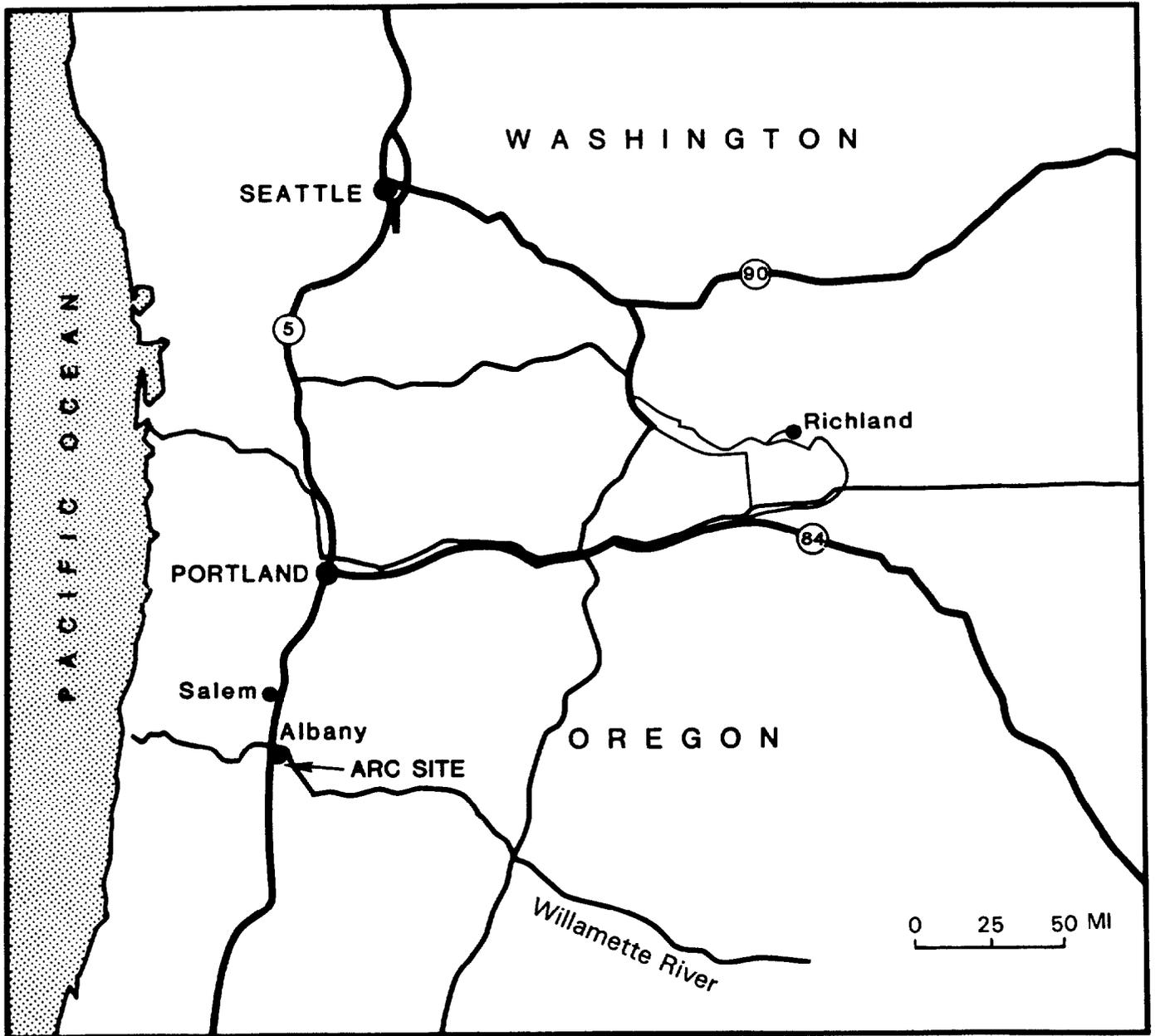


FIGURE 2-1 LOCATION OF THE ALBANY RESEARCH CENTER (ARC)

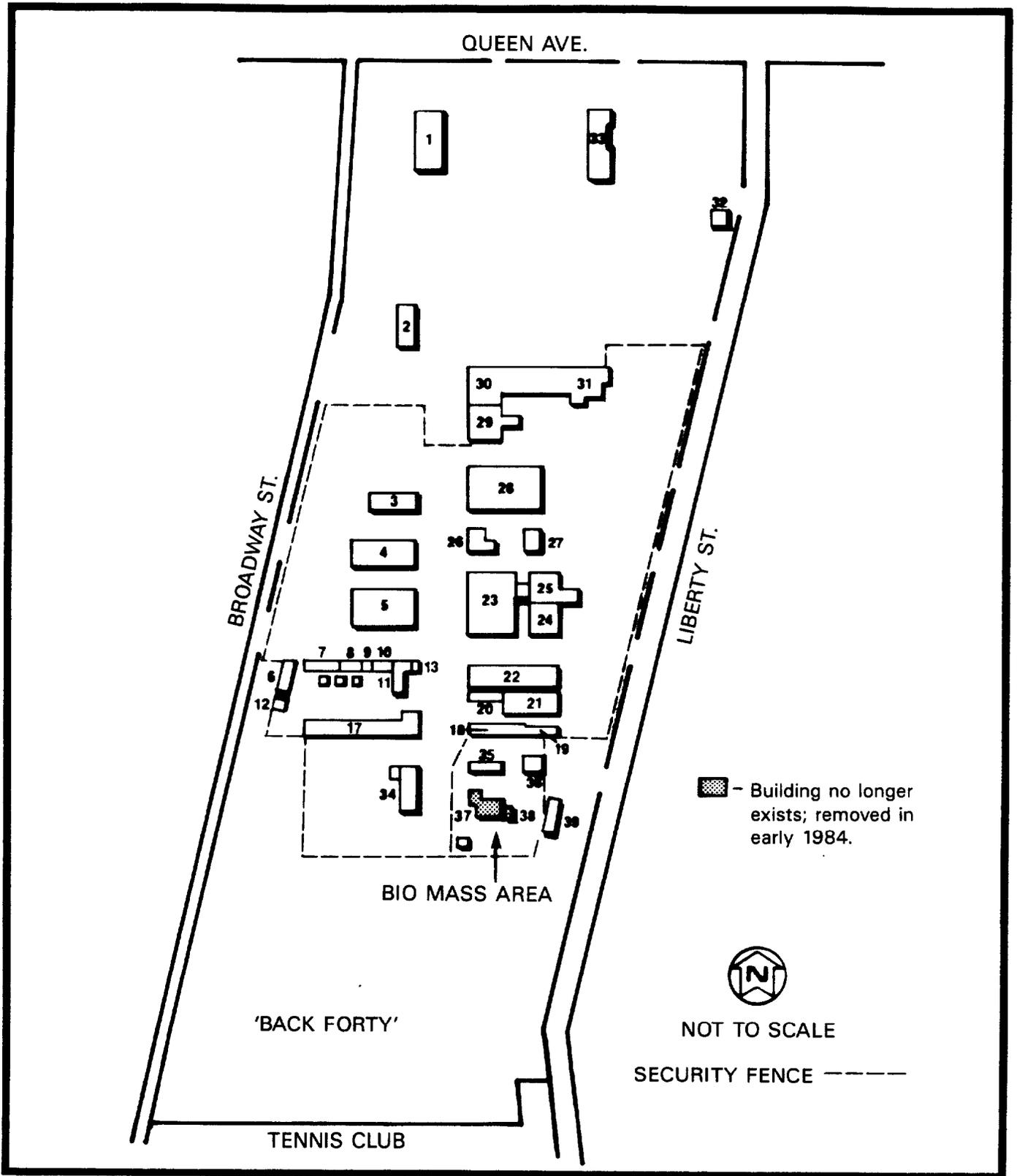


FIGURE 2-2 PLAN VIEW OF THE ARC SITE

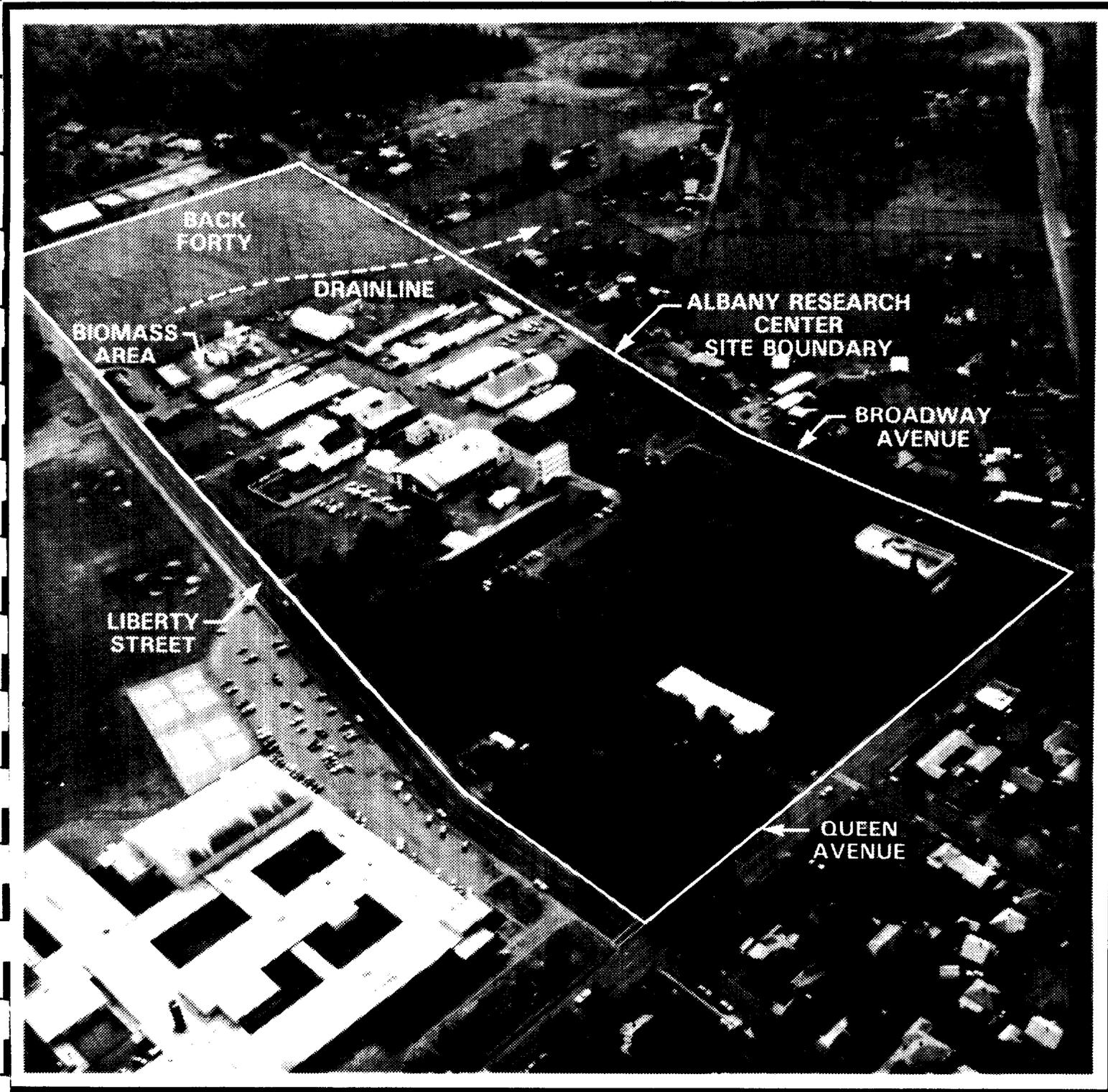


FIGURE 2-3 AERIAL PHOTOGRAPH OF THE ARC SITE (LOOKING SOUTHWEST)

in 1978 when the work at the ARC was terminated. For example, there were no cleanup guidelines for radionuclides in soil. Records relating to the decontamination effort were not adequate to determine if the buildings and surrounding areas met the 1978 DOE radiological guidelines. As a result, and at the request of DOE, a radiological assessment of ARC was initiated by ANL. The results of this assessment are reported in Subsection 2.3.

2.3 PREVIOUS RADIOLOGICAL SURVEYS

From June 1978 through September 1982, ANL conducted various surveys of the buildings and grounds on the ARC site to determine the radiological conditions. Building 4 and Building 30 were not included in the ANL survey. These were surveyed in 1981 by A. H. Environment, Inc. (Ref. 3).

Results of the ANL survey indicated that of the 34 buildings located on the ARC site, 10 contained some degree of contamination. Buildings 1, 5, 17, 23, 25, 26, 27, 28, 30 (Room 8) and 31 contained a few, small areas above remedial action guidelines. No contamination above guidelines was observed in the 5 buildings located in the Biomass area (Refs. 1 and 2).

Argonne reported grounds contamination at 26 locations on unpaved areas and at 33 locations on paved areas. The vertical extent of contamination was generally confined to the first foot of soil. The deepest contamination exceeding DOE guidelines was at a depth of 1 m (3 ft). The contamination consisted mainly of natural thorium, with lesser amounts of normal uranium. Because ANL did not employ a site grid system, the exact boundaries of the contamination could not be defined adequately for design engineering purposes (Refs. 1 and 2).

3.0 SURVEY PROCEDURES

3.1 FIELD SURVEY PROCEDURES

The survey grid system for the site was established for BNI by a civil surveyor during February 1984 and was based on the Oregon state geological plane. The grid consisted of mutually perpendicular lines spaced 15 m apart, as shown in Figure 3-1 (for ease of reference, all figures showing sampling locations are presented at the end of Section 3.0). Areas surveyed included those areas previously identified by ANL as having readings above background, plus all areas within 10 m of buildings on the site (Refs. 1 and 2).

3.1.1 Measurements Taken and Methods Used

Within the grid blocks of all field areas, beta-gamma dose rate measurements were made on the ground surface at 2.5-m intervals. The measurements were made using a pancake geometry Geiger-Mueller probe coupled to a digital ratemeter/scaler [Eberline Instrument Corporation (EIC) models HP-210 and PRS-1, respectively].

Also at 2.5-m intervals within the grid, near-surface gamma measurements were made 30 cm above the ground using a 5 cm x 5 cm sodium-iodide (NaI) detector. This detector (EIC model SPA-3) was mounted in a probe assembly surrounded with a conical lead shield to reduce the gamma intensity through the sides, thus producing a downward directional response.

Gamma exposure rate measurements were made at 15 locations throughout the site grid system using a pressurized ionization chamber (PIC). This instrument has a response to gamma radiation which is proportional to exposure in roentgens. At each of these 15 locations, a measurement was also made with an unshielded SPA-3 detector mounted on a tripod. A conversion

factor for SPA-3 measurements was established through a correlation of these two measurements at the 15 locations. The unshielded SPA-3 readings were then used to estimate gamma exposure rates for those locations shown in Figure 3-2.

Boreholes 15 cm in diameter were drilled in the areas shown in Figure 3-3. The locations and number of holes in each area were based on surface measurement results and the ANL survey data. A section of 10-cm diameter PVC plastic pipe with a closed bottom was inserted into each hole as a temporary sleeve to allow gamma logging. A 5-cm x 5-cm NaI (Tl) gamma scintillation detector (SPA-3 NaI crystal in a modified probe used specifically for borehole logging) was lowered into the pipe to obtain a profile of the depth of contamination. The detector was coupled with a PRS-1 ratemeter/scaler. Timed gamma measurements were made at 15 cm vertical intervals. These measurements were calibrated against the results from laboratory analyses of soil samples collected from boreholes (see Figure 3-5) to determine a correlation between counts per minute (CPM) and pCi/g. Subsurface soil samples were collected using Shelby tube sampling techniques.

3.1.2 Sample Collection and Analyses

Surface (0- to 15-cm-deep) soil samples were collected from areas where near-surface gamma levels or surface beta-gamma rates exceeded site background by a factor of three. These surface soil sample locations are shown in Figure 3-4. Each sample was placed in a 0.5-liter plastic container, capped and labeled. The samples were analyzed for radium-226, thorium-232, and uranium-238 using gamma spectrometry techniques. Each sample was counted for 10 minutes using an intrinsic germanium detector housed in a lead counting cave lined with cadmium and copper. The pulse height distribution was sorted using a computer-based multi-channel analyzer. Estimates of the concentration of individual radionuclides were made following a comparison of the gamma spectrum of each sample with the spectrum of a certified counting standard.

Subsurface soil samples were taken at locations shown in Figure 3-5. Undisturbed soil samples were collected using thin-walled Shelby tubes. Core samples were divided into approximately 10-cm increments, placed in 0.5-liter plastic containers, cupped, and labeled. Samples were analyzed in the same manner as the surface soil samples. Radionuclide concentrations in these samples were used to obtain the calibration factor for gamma logs of boreholes.

As shown in Figure 3-5, three samples of subsurface soils from the disposal area were collected to determine the presence of chemical contaminants listed among the Environmental Protection Agency's (EPA) priority pollutants. These samples were collected, packaged, and preserved in accordance with EPA procedures. Each sample was analyzed for moisture content, chloride, cyanide, fluoride, nitrogen (nitrate), phenol, phosphate (total), sulfate, pesticides, acid and base/neutral organics, volatile organics, and 35 metals. These data are required to provide documentation of chemical contaminants, if any, to ensure that proper industrial safety precautions are applied during the remedial action phase.

On-site surface water samples were collected from areas which had standing water. Fifteen samples were taken at locations related to the site's grid, as shown in Figure 3-6. In addition, a sample was taken from a swampy area west of Building 34, and another sample was taken from the ditch south of the waste dump area. The coordinates of the latter two samples were not recorded, and the locations shown in Figure 3-6 are approximate.

Off-site surface water samples were collected from a shallow underground drainline that crosses the north end of the Back Forty area of the site and flows northwest under Broadway and adjacent vicinity property to an outfall at the drain's intersection with Queen Avenue. Beginning on January 6, 1984, a

one-liter sample was collected from this outfall three times each week and composited into a single weekly sample. These samples were collected for 14 weeks.

Surface water samples were shipped to the Eberline laboratory in Albuquerque, New Mexico, where they were analyzed for suspended and dissolved thorium-232, radium-226, and total uranium using standard radiochemical techniques.

On-site subsurface water samples were collected from those boreholes located in areas suspected of contamination and from areas adjacent to the tile field in the Back Forty. Sampling locations are shown in Figure 3-7. Seven off-site groundwater samples were collected from manholes and culverts. Subsurface samples were analyzed for dissolved and suspended thorium-232, radium-226, radium-228, total uranium, uranium-238, uranium-235, and uranium-234 using standard radiochemical techniques.

Sediment samples were collected from drainage paths, sewers and septic tanks. The tile drain that underlies portions of the Back Forty was sampled to determine the extent of contamination (see Figure 3-8 for locations). These samples were collected using a clamshell, Ekman Dredge. The samples were analyzed for uranium-238, radium-226 and thorium-232 in the same manner as soil samples.

3.2 BUILDING SURVEY PROCEDURES

The 10 buildings previously identified by ANL as being contaminated (see Subsection 2.3) were characterized during this survey. Building 4, Building 29, and Building 30 also were surveyed. The specific areas surveyed in the buildings were based upon the results of the ANL and A. H. Environment surveys, plus information supplied by the ARC staff (Refs. 1, 2, and 3). The areas surveyed followed a 1 m x 1 m grid established on the floors and, when applicable, on lower and upper walls. "Lower walls" describes the area from the floor to the height of 1 m

above the floor. "Upper walls" are areas above 1 m. Ceiling beams, ventilation systems, and equipment suspected of contamination in several buildings also were surveyed. The openings of certain drains in some buildings were characterized. The specific areas surveyed in each building are described in Section 4.0, Survey Results.

The ANL surveys had indicated levels of airborne radioactive materials and gases were below applicable guidelines. Therefore, no air sampling was conducted during this survey.

The floors and, when applicable, the walls in each surveyed building area were monitored for alpha and beta-gamma radiation on the 1 m grid. An alpha surface measurement was made in the center of each grid segment using a 59-cm² zinc sulfide (ZnS) scintillation probe (EIC model AC-3), coupled with a PRS-1 ratemeter/scaler instrument. Beta-gamma dose rates were made in the same grid section locations as the alpha measurements. Beta-gamma measurements were made using a thin-window (7 mg/cm²) Geiger-Mueller detector (EIC Model HP-210). The detectors were in contact with the floor and wall surfaces during one-half minute counts. Areas with elevated readings were smeared for transferable contamination. In many instances, alpha and beta-gamma measurements were made along the intersections between floors and walls. This was especially true for those areas where residual material was likely to have been deposited in floor cracks due to the nature of previous operations.

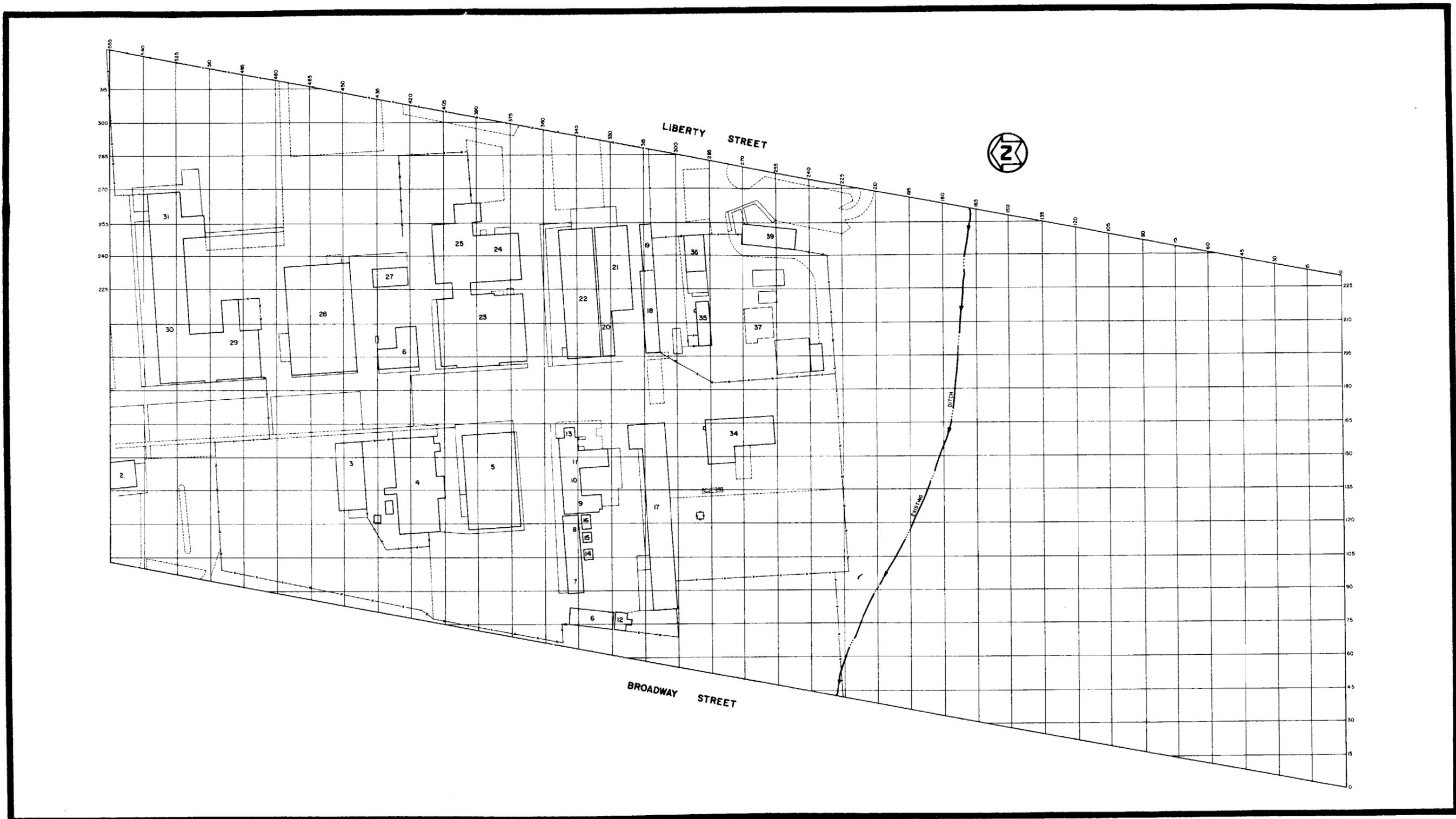


FIGURE 3-1 GRID FOR THE RADIOLOGICAL SURVEY OF THE ARC SITE

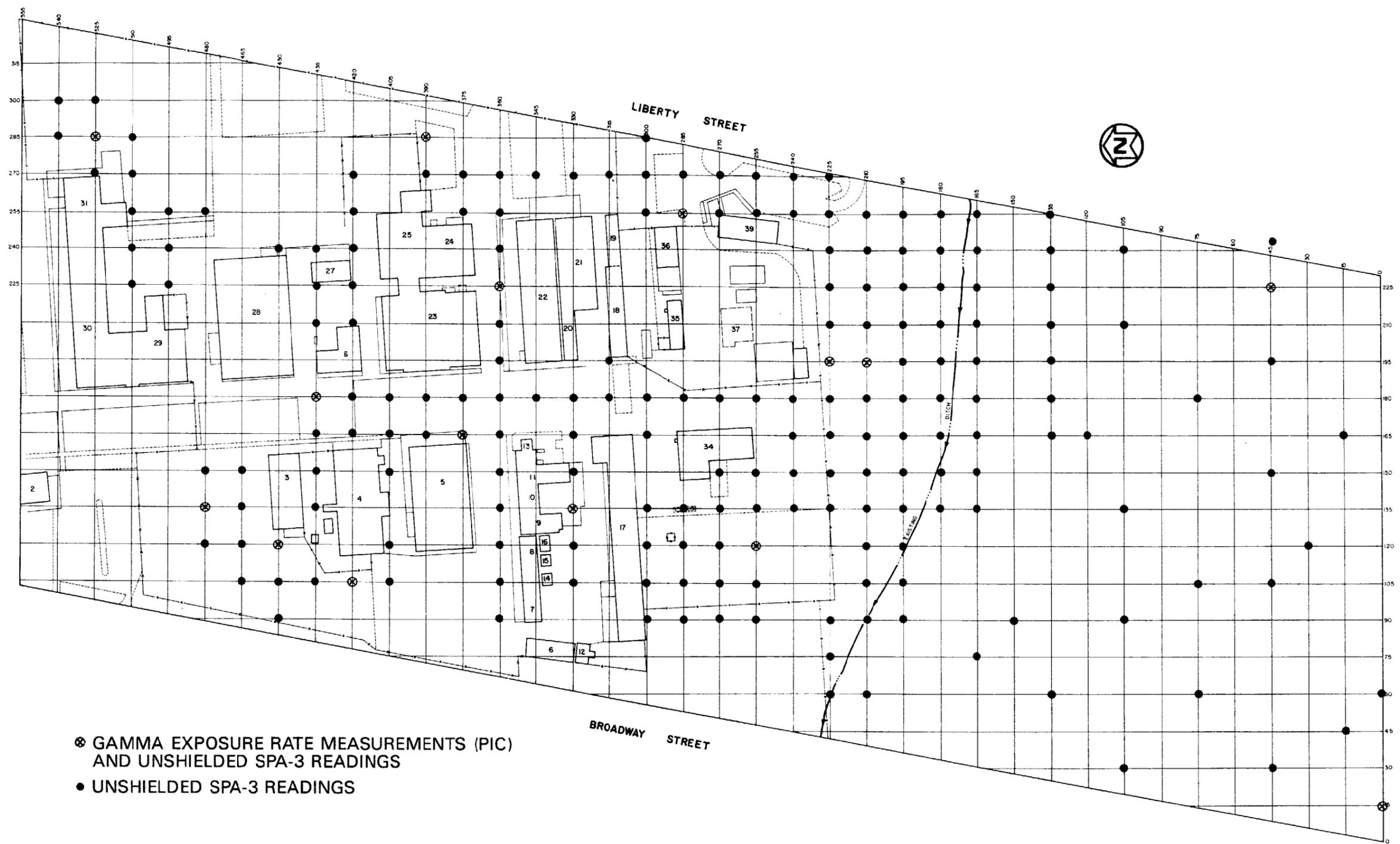


FIGURE 3-2 GAMMA COUNT RATE (1 M ABOVE GROUND) AND GAMMA EXPOSURE RATE MEASUREMENT LOCATIONS

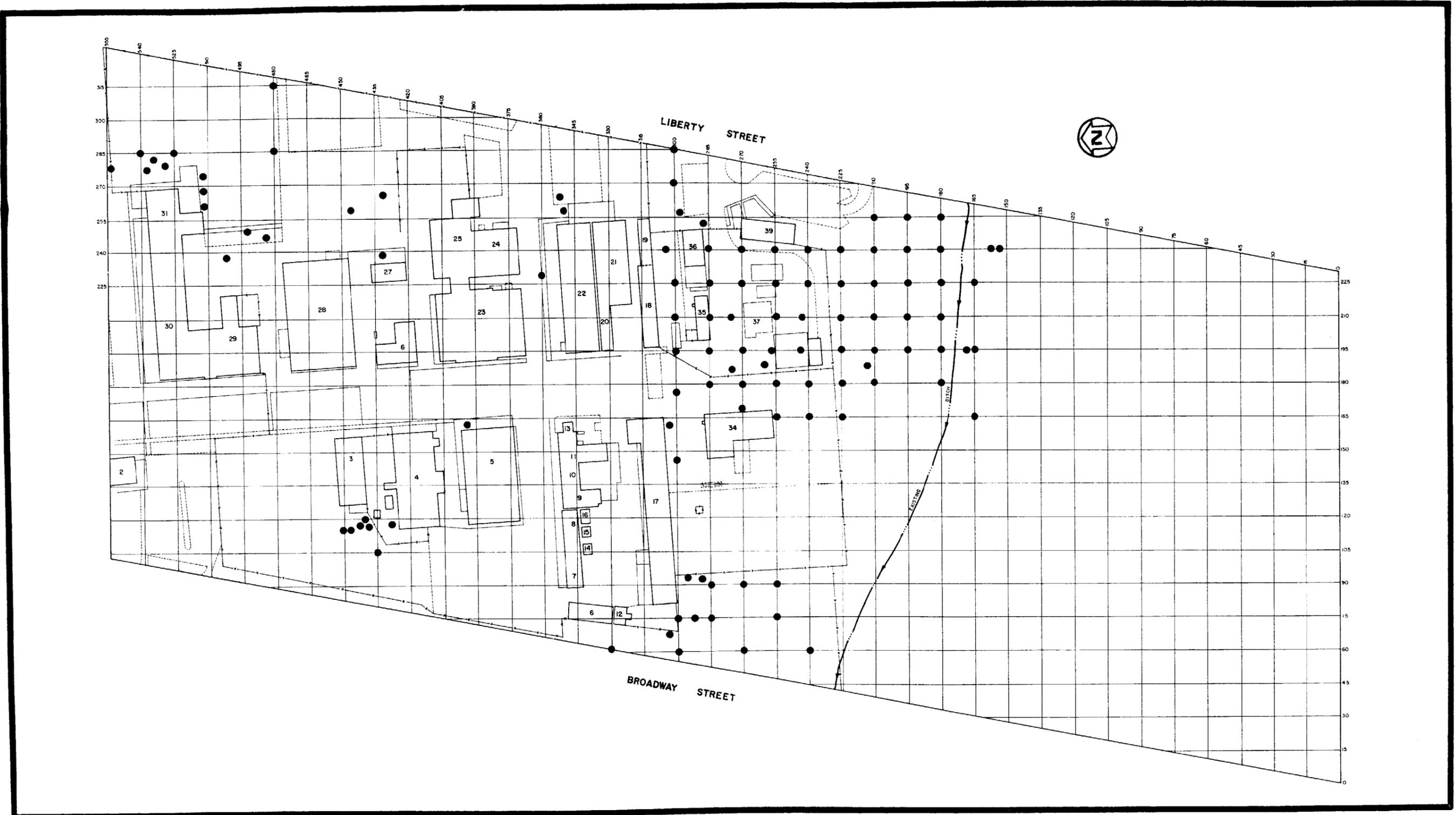


FIGURE 3-3 LOCATION OF BOREHOLES DRILLED AT ARC SITE DURING 1984 RADIOLOGICAL SURVEY

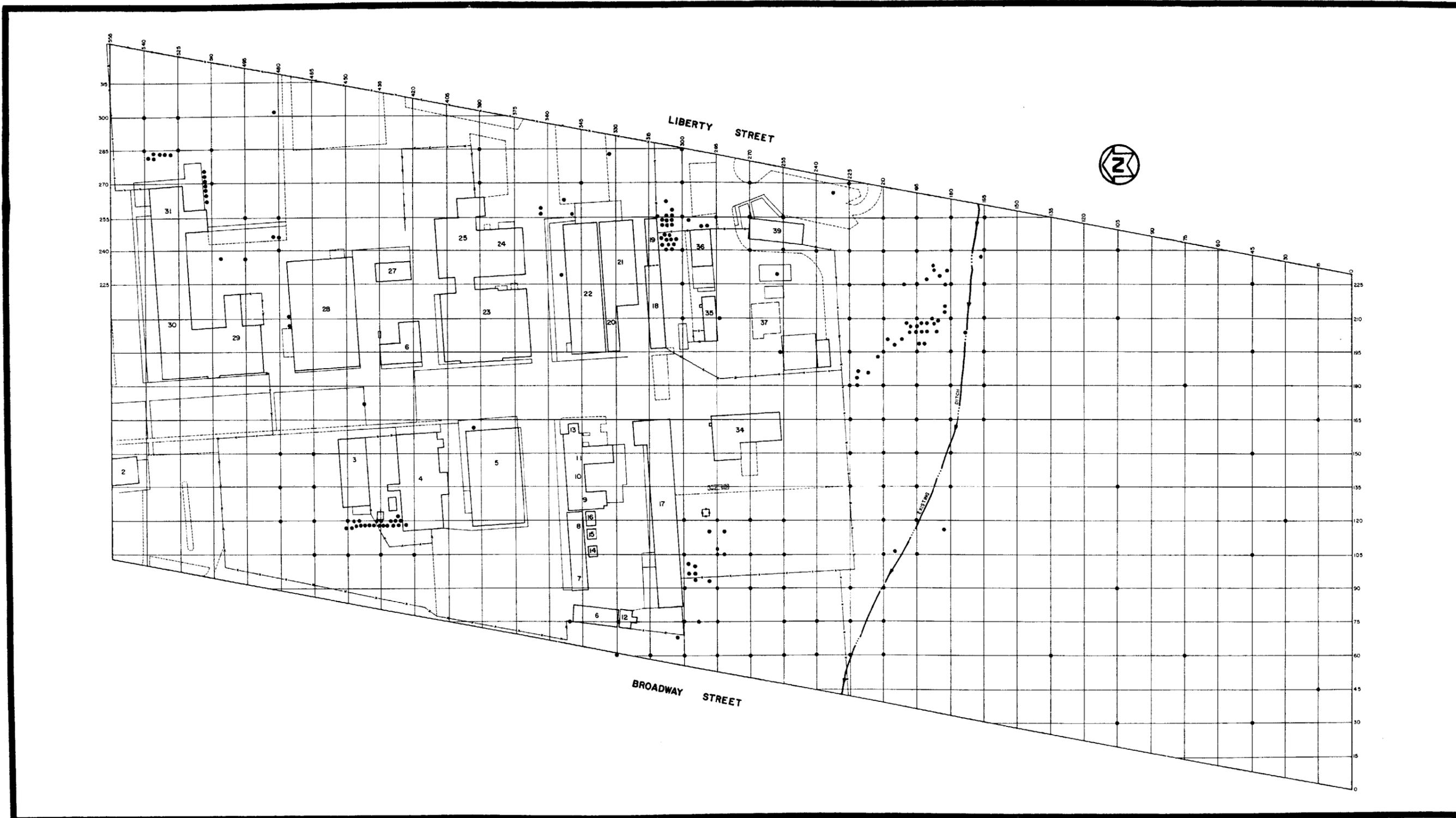


FIGURE 3-4 SURFACE SOIL SAMPLE LOCATIONS

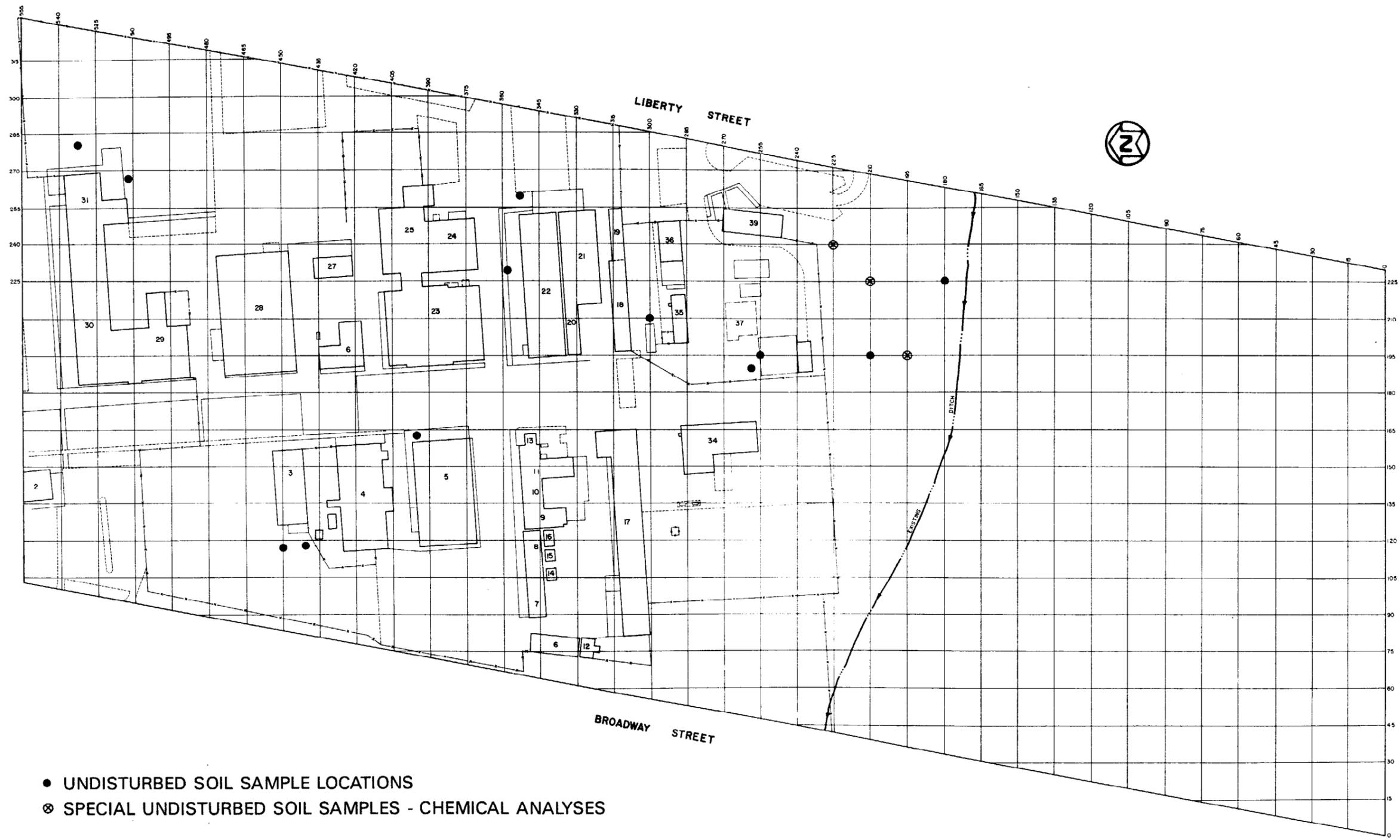


FIGURE 3-5 SUBSURFACE SOIL SAMPLE LOCATIONS

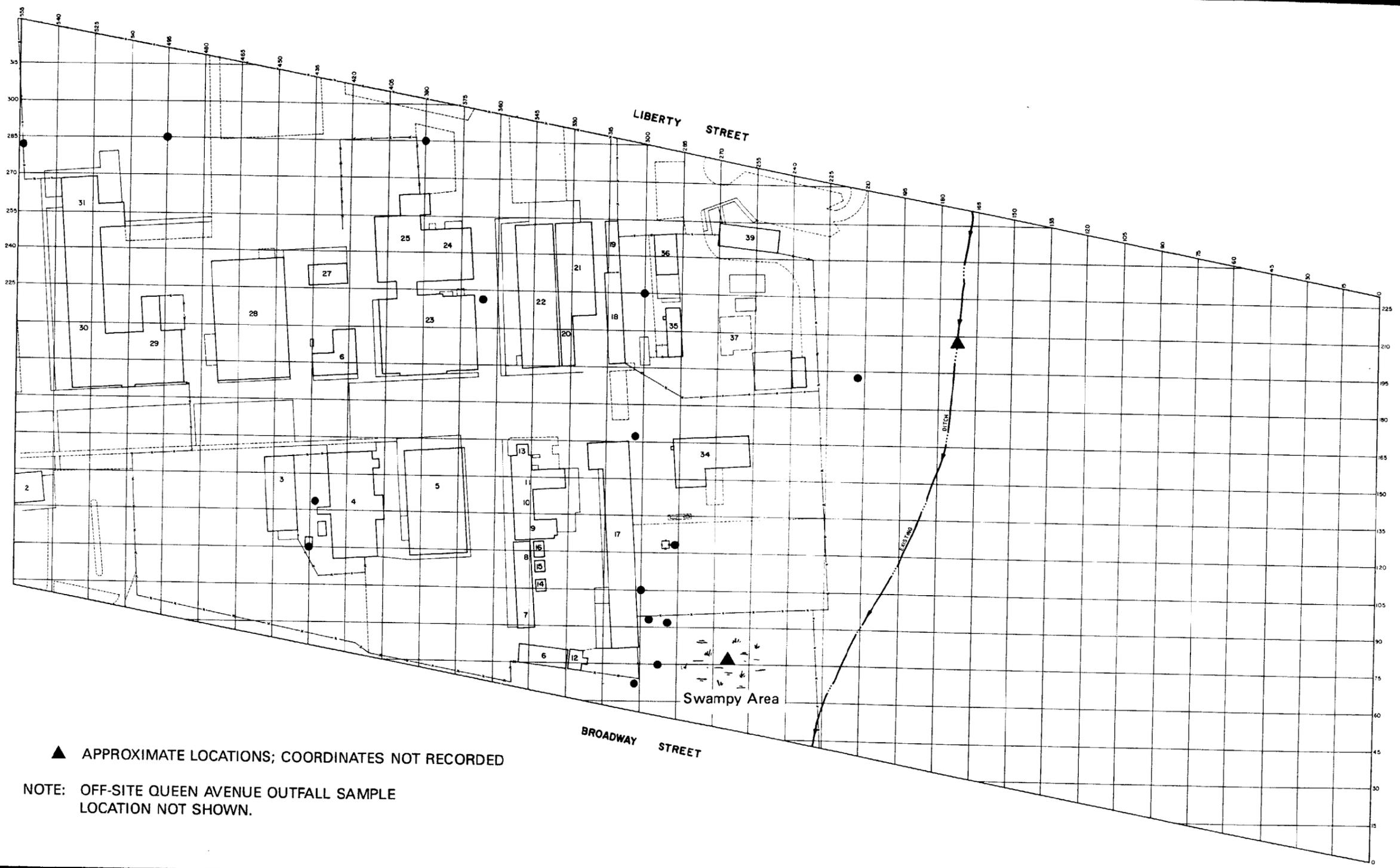


FIGURE 3-6 SURFACE WATER SAMPLE LOCATIONS

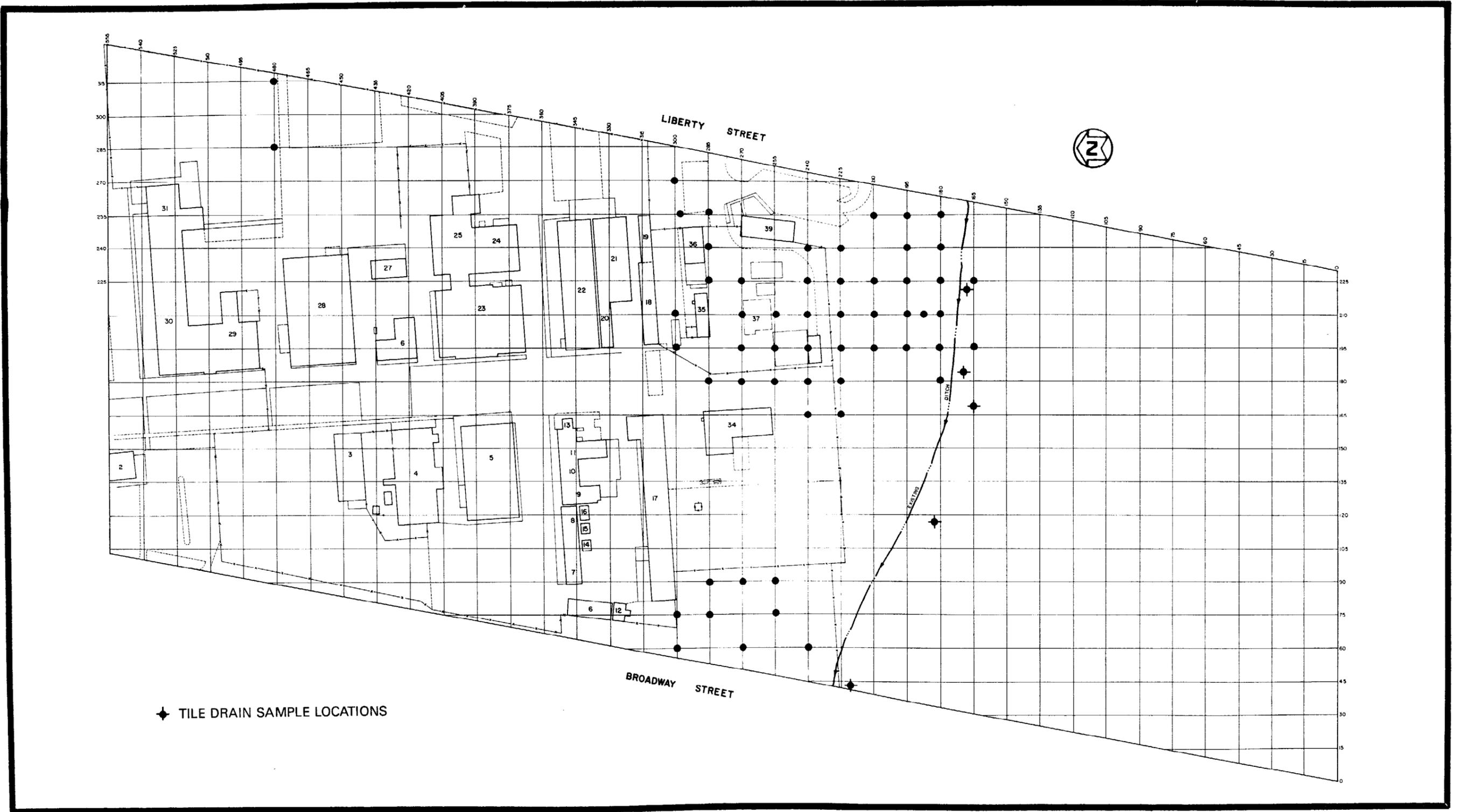


FIGURE 3-7 SUBSURFACE WATER SAMPLE LOCATIONS

4.0 SURVEY RESULTS

4.1 BACKGROUND MEASUREMENT RESULTS

Background measurements were made as part of this survey. At six locations in the Albany area, at distances ranging from 500 to 3700 m from the nearest area in which radioactive materials were handled or stored, surface soil samples were taken for determination of radionuclide concentrations. Concentrations of uranium-238 in the background soil samples were below the minimum detectable activity (MDA) levels (less than 1.0 pCi/g). Radium-226 concentrations ranged from below MDA (less than 0.4 pCi/g) to 2.7 pCi/g and averaged 1.3 pCi/g. Thorium-232 concentrations ranged from below MDA (less than 0.2 pCi/g) to 1.2 pCi/g and averaged 0.8 pCi/g.

At the same six background locations, near-surface gamma levels, surface beta-gamma dose rates, and gamma exposure rates were also measured. Gamma exposure rates ranged from 6.1 uR/h to 9.1 uR/h. The average background exposure rate in the Albany area was 7.9 uR/h. All background measurements are summarized in Table 4-1, presented at the end of Section 4.0.

In addition to these background data, a series of additional external gamma exposure rate measurements were made throughout the state of Oregon. Exposure rate measurements in the southern part of the state averaged 11.0 uR/h (Ref. 4).

During this survey, three surface water samples and one groundwater sample which were assumed to represent background concentrations were collected. Surface water samples were collected at points ranging from approximately 500 m to 1700 m from the ARC site. A water sample also was taken from the municipal water supply. All samples were analyzed for dissolved and suspended total uranium, radium-226 and thorium-232. All results of these samples were below MDA levels.

The MDA's for the background water samples were as follows: for dissolved radium-226, less than 0.1 pCi/l; for dissolved total uranium, less than 1.5 pCi/l; for dissolved thorium-232, less than 0.5 pCi/l; for suspended radium-226, less than 0.5 pCi/l; for suspended total uranium, less than 0.09 pCi/l; and for suspended thorium-232, less than 0.3 pCi/l.

4.2 FIELD SURVEY RESULTS

During this survey, in all field areas, measurements were taken for near-surface gamma radiation levels, surface beta-gamma dose rates, and gamma exposure rates 1 m above the ground. Boreholes were drilled and gamma logging was performed, and undisturbed (Shelby tube) soil samples, water samples, and sediment samples were taken in each area as appropriate. The results of these measurements and sample analyses are presented in the following subsections. For comparison purposes, current DOE guidelines for radionuclide concentrations in soil, sediment and water are presented in Table 4-2 at the end of Section 4.0 (Ref. 4).

All direct field measurements and laboratory results in this report represent gross readings; background radiation levels and radionuclide concentrations have not been subtracted.

4.2.1 Surface and Near-Surface Measurement Results

Near-surface gamma radiation levels measured on the ARC site ranged from 524 cpm to 68,942 cpm. (Elevated near-surface gamma radiation levels are considered to be those that are equal to or greater than twice background.) Gamma measurements at 1 m above the ground ranged from 5524 to 21,024 cpm, compared to a normal background of 6,413 cpm. These correspond to a gamma exposure rate of 5.8 to 22.2 uR/h. As noted earlier, the overall area background rate measured by BNI was 7.9 uR/h. The DOE criterion for continuous exposure to an individual in the general population is 60 uR/h above background (Ref. 5). Beta-gamma

dose measurements ranged from below background to 1.9 mrad/h. The DOE guideline is 0.20 mrad/h averaged over one square meter (Ref. 6). Near-surface gamma, beta-gamma dose rates, and gamma exposure rates are summarized in Table 4-3, presented at the end of Section 4.0.

4.2.2 Boreholes

One hundred and eight boreholes ranging in depth from 0.8 to 3 m were drilled on the ARC site. Borehole gamma logging was performed to indicate general depth and concentrations of contamination. (Detailed gamma logging results are not reported in this document but are available upon request from Bechtel National, Inc.) When possible, borehole gamma loggings were correlated with the radionuclide concentrations in undisturbed (Shelby tube) soil sample analyses, relating the gamma detector's count rate (cpm) to the specific radionuclide concentration in picoCuries per gram (pCi/g). Borehole locations where contamination was indicated to be above DOE guidelines are shown in Figure 4-1 at the end of Section 4.0.

4.2.3 Soil Samples

Surface soil samples were collected at points shown in Figure 3-4. These samples were analyzed for uranium-238, radium-226, and thorium-232. The major contaminant was found to be thorium-232, with concentrations ranging from less than 0.2 to 84.8 pCi/g. Radium-226 concentrations above the DOE guideline were also found in surface soils, with concentrations ranging from 0.4 to 68.0 pCi/g. Uranium-238 concentrations ranged from less than 1.0 to 37.5 pCi/g, below the DOE guideline of 150 pCi/g. Sampling locations which indicated contamination above the DOE guidelines are shown in Figure 4-2. Specific results are listed by sample coordinates in Table 4-4 at the end of Section 4.0.

Twelve undisturbed (Shelby tube) subsurface soil samples were taken on the ARC site at locations shown in Figure 3-5. The results of gamma spectrometry analysis revealed thorium-232 is the major contaminant, with levels ranging from less than 0.2 to 232.1 pCi/g. Concentrations of radium-226 above the DOE guideline were also found. Subsurface radium-226 concentrations ranged from less than 0.4 to 143.6 pCi/g. Uranium concentrations were below the guideline, with concentrations ranging from less than 1.0 to 34.8 pCi/g. Locations showing subsurface contamination above guidelines are shown in Figure 4-3 at the end of Section 4.0. Specific results are presented by coordinate and depth in Table 4-5 at the end of Section 4.0.

Three subsurface soil samples were collected from the ARC disposal area for determination of non-radiological parameters. EPA priority pollutants were analyzed, with trace amounts of trichloroethane, B-BHC, heptachlor epoxide, dieldrin, PCB-1254, P,P-DDD (4,4'), endosulfan sulfate, and a variety of metals found to be within the soil (Ref. 7). The levels measured would not present occupational health hazards by inhalation or skin absorption to individuals in contact with the soil during remedial action operations.

4.2.4 Sediments

Nine sediment samples were collected from the ARC site (see Figure 3-8). Sediment samples analyses results are given in Table 4-6 at the end of Section 4.0. Uranium-238 concentrations ranged from less than 1.0 to 789.5 pCi/g; radium-226 ranged from less than 0.4 to 44.7 pCi/g, and thorium-232 ranged from less than 0.2 to 33.9 pCi/g. Three samples indicated concentrations above the DOE guidelines, and these locations are indicated on Figure 4-4.

The results of analyses of the two Tile Drain sediment samples ranged from 1.3 to 2.6 pCi/g for radium-226. Thorium was

present in only one sample, at a concentration of 1.5 pCi/g. Uranium-238 was not found in either of the two Tile Drain samples.

Nine off-site sediment samples collected from vicinity properties (see Figure 3-8) were analyzed. The radionuclide concentrations in these samples were below the DOE guidelines. Specific results are given in Table 4-6.

4.2.5 Water Samples

On-site surface water samples were collected at points shown in Figure 3-6. Fourteen weekly off-site composite samples were collected from the Queen Avenue outfall. Surface water samples were analyzed for dissolved and suspended thorium-232, radium-226, and total uranium. None of the surface water samples revealed radioactivity above the DOE criteria. Specific results are given in Table 4-7.

Sixty-one on-site groundwater samples were collected during this survey. Sampling locations are shown in Figure 3-7. All water samples were analyzed for dissolved thorium-232, radium-226, and total uranium. Samples collected from the boreholes drilled in the area of the waste dump were also analyzed for suspended thorium-232, radium-226, and total uranium. Five additional on-site subsurface water samples were collected from the Tile Drain area located in the Back Forty. These samples were analyzed for dissolved and suspended thorium-232, radium-226, radium-228, total uranium, uranium-238, uranium-235, and uranium-234. All groundwater radionuclide concentrations were below the DOE criteria.

All radionuclide concentrations in off-site groundwater samples collected from manholes and culverts in the vicinity of the site were below DOE criteria. Specific results are given in Table 4-7.

4.3 BUILDING MEASUREMENT RESULTS

During this survey, portions of Buildings 1, 4, 5, 17, 19, 23, 25, 27, 28, 29, 30, and 31 were examined for contamination. The locations of the areas surveyed in each building were selected based on the results of the ANL surveys (Refs. 1 and 2). The measurements taken and methods used in the buildings are described in Subsection 3.2.1. The results of those measurements for each building are summarized in the following subsections. The type and number of measurements made in each area and the ranges of measured values are detailed in Table 4-8, presented at the end of Section 4.0.

For those buildings and/or areas which exhibited contamination above guidelines, illustrations are provided to show the location and type of contamination. These figures are presented at the end of Section 4.0 and are referenced in the appropriate subsection.

All building survey measurements represent gross readings; background measurements and concentrations have not been subtracted.

4.3.1 Building 1

A 2 m x 2 m area on the floor of the electrical room in Building 1 was gridded. The contaminated area reported by ANL was found not to exceed guidelines. The beta-gamma dose rate was 0.03 mrad/h, compared to the DOE dose rate limit of 0.2 mrad/h. The alpha surface measurement was 56 dpm/100 cm² compared to the remedial action guideline limit (based on thorium-232 contamination) of 1000 dpm/100 cm². The guideline for surface contamination at ARC is based on thorium-232. Selection of this guideline was based on site operational history, which indicated that the primary material handled was thorium-232.

4.3.2 Building 4

In Building 4, the survey centered on the "Owl Room". This room comprises two levels, and each level's floor and walls were gridded and surveyed. Measurements also were taken at floor/wall intersections. The measured values for each level are summarized below. These values were in general agreement with a previous survey conducted by A. H. Environment, Inc. (Ref. 3).

First Level

Results of the survey of the first level of the Owl Room showed areas of above-guideline contamination. Beta-gamma dose rates above the DOE guideline of 0.20 mrad/h were recorded at locations on the first level floor, walls, and floor/wall intersections. On the floor, beta-gamma dose rates ranged from 0.02 to 5.54 mrad/h. On the walls, the range was less than 0.01 to 0.65 mrad/h. Floor/wall intersection beta gamma dose rates ranged from 0.02 to 0.7 mrad/h..

Surface alpha contamination above the DOE guideline of 1000 dpm/100 cm² was measured at locations on the floor and floor/wall intersections. On the floor, surface alpha contamination ranged from 28 to 5464 dpm/100 cm²; at floor/wall intersections, the range was 37 to 3344 dpm/100 cm².

Smear sample results showed transferable alpha contamination above the DOE guideline of 200 dpm/100 cm² at two locations, both at floor/wall intersections. The range of readings was less than 2.2 to 270 dpm/100 cm².

The type and number of measurements made on the Owl Room's first level and the range of the results are presented in Table 4-8. The locations and type of above-guideline contamination are depicted in Figure 4-5.

Second Level

The results of the survey of the second level of the Owl Room showed all measurements below guidelines except beta-gamma dose rates. Two grid areas showed measurements above the DOE beta-gamma dose rate guideline of 0.20 mrad/h. The range of levels recorded was 0.02 to 0.27 mrad/h.

The areas exceeding the guideline are shown in Figure 4-6. Complete data on the survey of the second level are presented in Table 4-8.

Miscellaneous Equipment

Miscellaneous equipment stored in the Owl Room was surveyed for beta-gamma dose rates, direct alpha, and transferable alpha and beta contamination. Beta-gamma dose rates ranged from 0.01 to 55.8 mrad/h, compared to the DOE guideline of 0.20 mrad/h. Surface alpha readings ranged from 0 to 10,484 dpm/100 cm², compared to the DOE guideline of 1000 dpm/100 cm². Measurement of all equipment presently stored in the Owl Room indicated either surface alpha or beta-gamma dose rates above DOE guidelines. In addition, transferable alpha contamination on the equipment was found to exceed the guideline. The equipment and the transferable alpha levels on each piece are detailed below:

<u>Government No.</u>	<u>Equipment Description</u>	<u>Alpha (dpm/100 cm²)</u>
50266	Hacksaw - vicejaws	337
36274	Surface grinder - trough	353
---	Glove box - sand blaster Serial No. Techline A-10863	818
---	Glove box - inside circular turn table Serial No. Techline A-10863	849
51306	Lathe - exhaust duct	209

Two filter inlets had beta-gamma dose rates above the DOE guideline. The filter locations are indicated in Figure 4-5. Filter outlet measurements were below the guideline. A complete summary of the data from the survey of the Owl Room equipment is presented in Table 4-8.

4.3.3 Building 5

Inside Building 5, a portion of the Machine Shop floor was gridded and surveyed. Survey results showed beta-gamma dose rates and alpha surface contamination readings above guidelines in a small area of the room, with readings ranging from 0.01 to 0.27 mrad/h for beta-gamma dose rates and from 0 to 1973 dpm/100 cm² for surface alpha contamination. These readings compare to the DOE guidelines of 0.20 mrad/h and 1000 dpm/100 cm², respectively. The specific locations of the above-guideline contamination are shown in Figure 4-7. All smear samples taken for transferable alpha contamination were below the DOE guideline. Data are summarized in Table 4-8.

The metal storage room in Building 5 was scanned, and random beta-gamma and alpha radiation measurements were made. As shown in Table 4-8, all measurements were below DOE guidelines.

4.3.4 Building 17

In Building 17, a partial grid was established in Room 10 and the area was surveyed for beta-gamma dose rates, direct alpha, and transferable alpha and beta contamination. One location in the gridded area was found to have beta-gamma dose rates above the DOE guideline of 0.20 mrad/h. The highest beta-gamma dose rate recorded was 0.21. One location exhibited surface alpha contamination above the DOE guidelines of 1000 dpm/100 cm², with a maximum reading of 1139 dpm/100 cm². These locations are illustrated in Figure 4-8.

Smear samples showed transferable alpha contamination below the DOE guideline. The summary of data for Room 10 is reported in Table 4-8.

Also in Building 17, Lab 8, Lab 9, a hallway passing by the two labs into Room 10, and an upstairs storage room (presently used for storage of naturally radioactive materials) were scanned during the survey. Random beta-gamma and surface alpha contamination measurements were made in the hallway and Lab 9. All measurements were below DOE guidelines. Data from the hallway and Lab 9 measurements are presented in Table 4-8.

4.3.5 Building 19

The radiological examination of Building 19 centered on a fume hood stored in the building that was found to have contamination on the interior surfaces. During the beginning of this survey, Building 19 also was used for the storage of waste materials that were shipped off-site before the completion of the survey. The building was scanned in order to ensure that leakage of waste from the storage barrels had not occurred. No areas of elevated contamination were located.

A smear sample for transferable contamination was taken and results were below the DOE guidelines for transferable alpha. The smear sample data are reported in Table 4-8.

4.3.6 Building 23

Based on the results of the ANL survey (Ref. 1), in Building 23 the radiological survey investigated an area in a hopper storage area (beneath Hopper 4), an area in a sump in the building's basement, and the doorway to the Old Thorium Lab. Smear samples taken in these areas showed transferable alpha contamination well below the DOE guideline of 200 dpm/100 cm². Data are reported in Table 4-8.

In addition, three trenches outside the Old Thorium Lab were investigated (see Figure 4-9). Residues (dust from floor sweepings) inside the trenches were sampled and analyzed for thorium-232, radium-226, and uranium-238. The maximum results were 53 pCi/g, 26 pCi/g, and 13 pCi/g, respectively. Dust samples were also collected from the overhead beams and vertical surfaces, and a sample was composited and analyzed. Results showed thorium-232 concentrations of 1.6 pCi/g, and radium-226 concentrations of 1.8 pCi/g. Uranium-238 concentrations were below detectable levels.

4.3.7 Building 25

In Building 25 the survey investigated the second level for any readings above guidelines. The survey centered on three furnace tops (exterior surfaces), which were checked for beta-gamma dose rates, surface alpha contamination, and transferable alpha and beta contamination. As shown by the data in Table 4-8, all results were below DOE guidelines. Building 25 is presently used for storage of barrels containing wastes of naturally radioactive materials.

4.3.8 Building 26

The ANL survey (Ref. 1) had indicated two areas inside Building 26 with readings above background. During the 1984 survey, these same areas were scanned for elevated readings. No contamination above guidelines inside Building 26 was located during the 1984 survey.

4.3.9 Building 27

In Building 27, the floor of Room 102 was gridded and surveyed, and measurements were taken for beta-gamma dose rates, surface alpha contamination, and transferable alpha and beta contamination. In some locations, beta-gamma dose rates and surface alpha contamination exceeded the DOE guidelines of 0.20 mrad/h and 1000

dpm/100 cm², respectively. Beta-gamma dose rates ranged from 0.08 to 6.77 mrad/h, and surface alpha readings ranged from 65 to 3881 dpm/100 cm². The above-guideline locations are shown in Figure 4-10. Data are presented in Table 4-8.

Smear samples were taken from contaminated areas and analyzed for transferable alpha and beta contamination. All results were below the DOE guideline for transferable alpha. Data are presented in Table 4-8.

4.3.10 Building 28

In Building 28, the corridor leading into Room 15 was gridded and surveyed, and measurements were taken for beta-gamma dose rates and surface alpha contamination. The results of the measurements showed one location which exhibited both beta-gamma dose rates and alpha contamination above the DOE guidelines, with beta-gamma dose rates in the location reaching 0.45 mrad/h, and alpha contamination readings reaching 1186 dpm/100 cm². This location is shown in Figure 4-11. Data from the measurements are presented in Table 4-8. A smear sample taken from the location showed transferable alpha contamination well below the DOE guideline. These data also are reported in Table 4-8.

4.3.11 Building 29

All areas of Building 29 were scanned and checked for beta-gamma and alpha contamination. The survey covered areas of 13 rooms, a hallway, rafters, filter casings, and the floor of the second level of the building. Only two above-guideline readings were located: a sink drain in Room 109 with a maximum beta-gamma dose rate of 5.96 mrad/h; and a floor drain in Room 111 with a maximum beta-gamma dose rate of 0.42 mrad/h. These readings compare with a DOE guideline of 0.20 mrad/h. The locations of these two areas are shown in Figure 4-12. It is important to note that only the openings of the drains were characterized. Based on surface measurements at these openings, the drainlines contain materials

which are above guidelines and will require either decontamination or removal during remedial action.

All other beta-gamma and transferable alpha contamination results in Building 29 were below DOE guidelines. Complete data on Building 29 are summarized in Table 4-8.

4.3.12 Building 30

Building 30 was previously surveyed in 1981 by A. H. Environment, Inc. (Ref. 3). BNI findings were in general agreement with the earlier survey. The BNI survey was focused on the Fabrication Room, the "Tower Base," the filtering system (outlets and inlets), miscellaneous equipment, and overhead beams. The floor and walls of the Fabrication Room were gridded and surveyed. Within the room, three areas were found which exceeded the DOE beta-gamma dose rate guideline of 0.20 mrad/h, with a maximum reading of 0.66 mrad/h. One area within the Fabrication Room exceeded the DOE guideline for surface alpha contamination (1000 dpm/100 cm²), with a maximum reading of 1042 dpm/100 cm². These above-guideline areas of contamination in the Fabrication Room are illustrated in Figure 4-13.

Results of smears taken in the room for transferable alpha and beta contamination were all below guidelines. Complete data for the Fabrication Room, Building 30, are presented in Table 4-8.

Results of the investigation of the filtering system showed several filter inlets exceeding the DOE guidelines for beta-gamma dose rates (0.20 mrad/h) and surface alpha contamination (1000 dpm/100 cm²). The beta-gamma dose rates on inlets ranged from 0.01 to 6.41 mrad/h, with alpha surface measurements ranging from 19 to 8984 dpm/100 cm². Filter inlets for which readings were above guidelines are shown in Figure 4-14. Filter inlets and outlets also were smeared for removable alpha and beta contamination. All smear results were below DOE guidelines. Complete data on the filtering system is presented in Table 4-8.

Two pieces of miscellaneous equipment in the Fabrication Room also exhibited beta-gamma dose rates and surface alpha contamination above guidelines. Beta-gamma dose rates ranged as high as 61.2 mrad/h, compared to the DOE guideline of 0.20 mrad/h. Surface alpha readings ranged as high as 39,686 dpm/100 cm², compared to the 1000 dpm/100 cm² guideline. These two pieces of equipment are a tube furnace, Government No. 38308, and a pump, Government No. 90423.

All other survey results in Building 30, from the Tower Base and the overhead beams, were below guidelines. Complete data are presented in Table 4-8.

4.3.13 Building 31

In Building 31, which shares a common wall with Building 30, the survey concentrated on the Workshop, where the floor, walls, floor/wall intersections, filtering system and overhead beams were investigated. On the Workshop floor, two locations revealed beta-gamma dose rates above the DOE guideline of 0.20 mrad/h, with readings ranging up to 0.34 mrad/h. These two locations are shown in Figure 4-13.

Also in Building 31, one filter inlet revealed beta-gamma dose rates and surface alpha contamination above DOE guidelines. Beta-gamma dose rates ranged as high as 7.57 mrad/h, and surface alpha readings reached 7206 dpm/100 cm². These readings compare with DOE guidelines of 0.20 mrad/h and 1000 dpm/100 cm², respectively.

All other measurements taken in the Workshop were below guidelines. Also, the Mechanical Testing Lab floor and drain ends, Room 8 walls, Room 13 floors and drain, and a hood in Room 14 all revealed no contamination above guidelines. A summary of measurements and results is presented in Table 4-8.

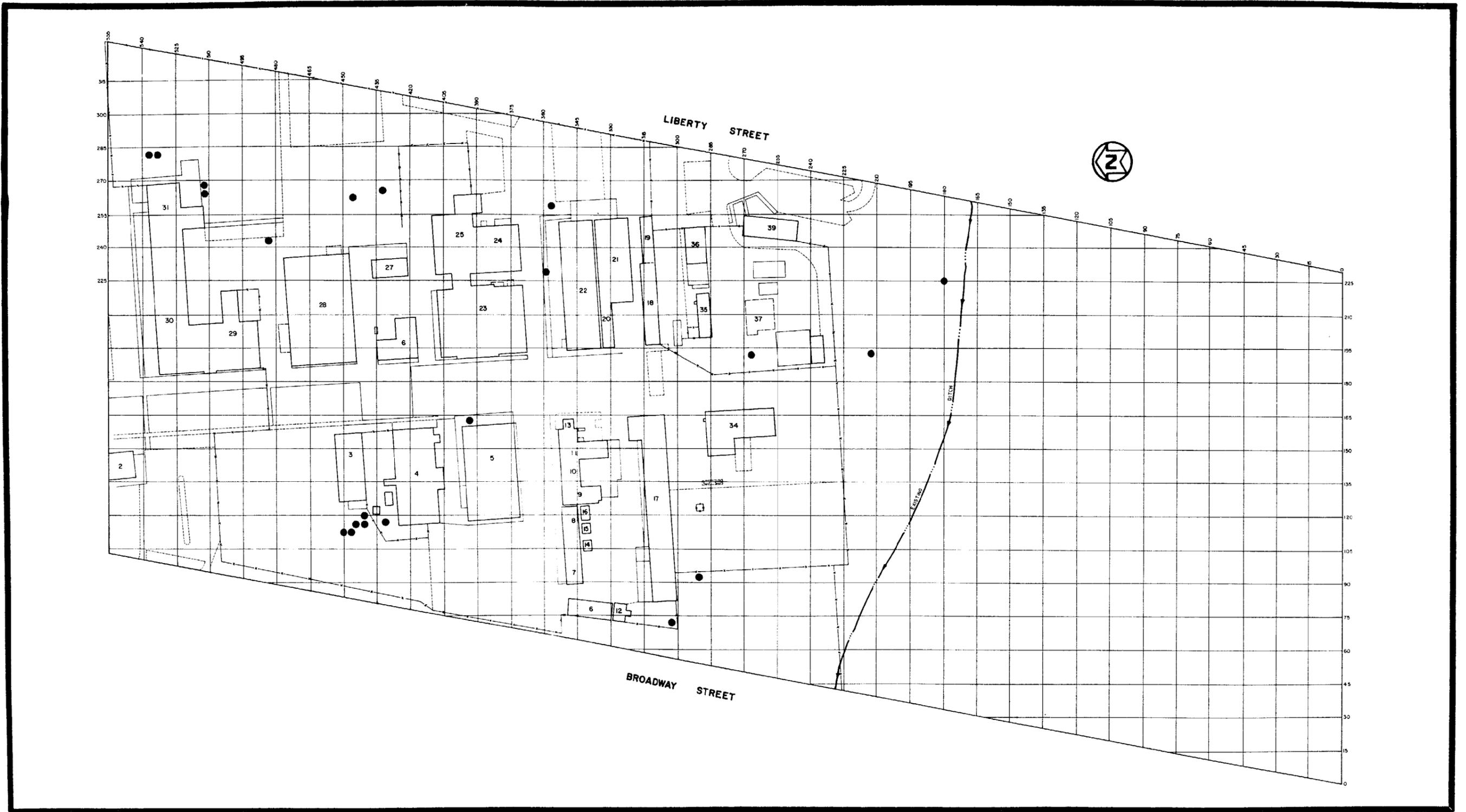


FIGURE 4-1 LOCATIONS OF BOREHOLES SHOWING CONTAMINATION ABOVE GUIDELINES

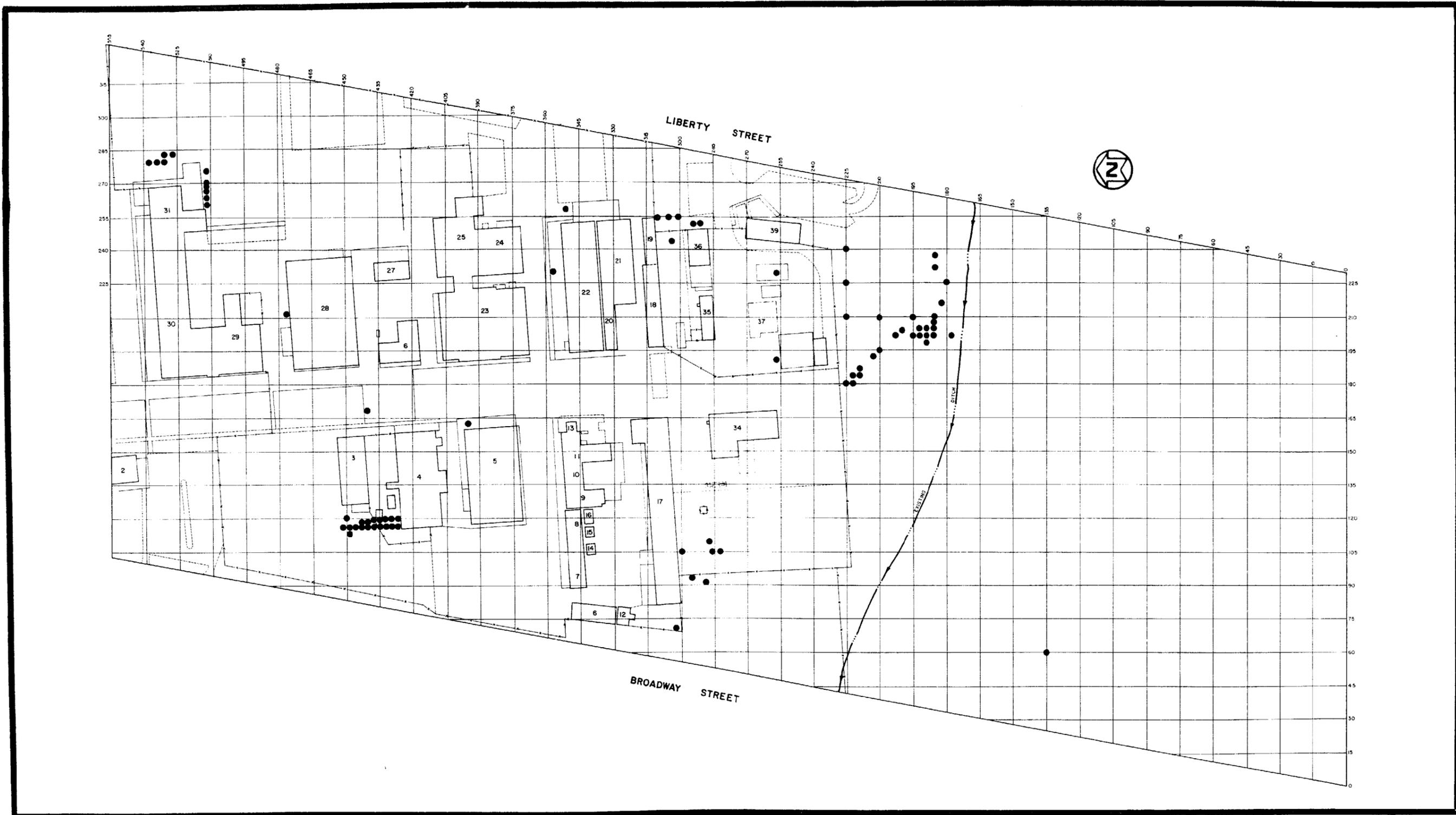


FIGURE 4-2 LOCATIONS SHOWING SURFACE SOIL CONTAMINATION ABOVE GUIDELINES

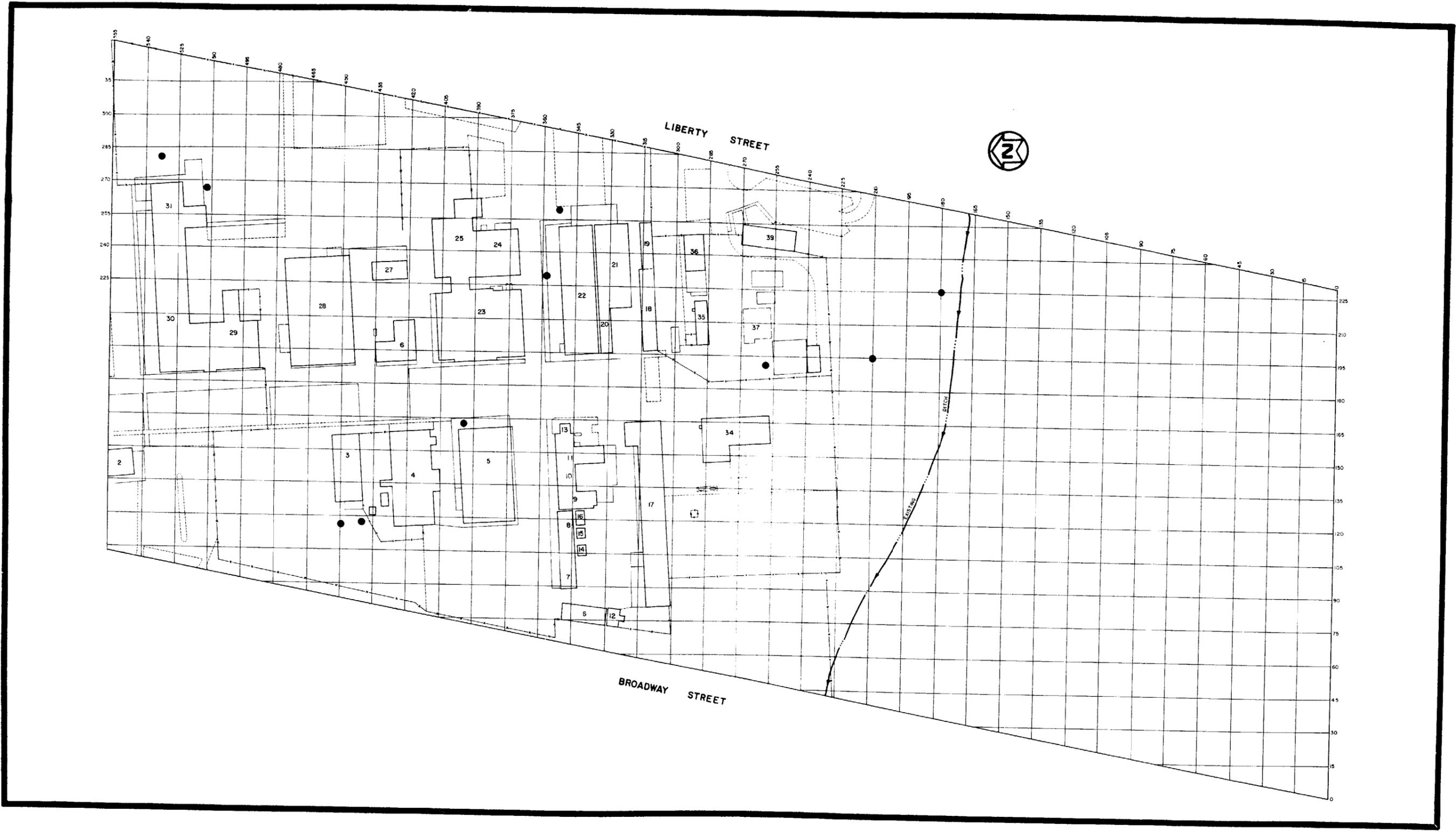


FIGURE 4-3 LOCATIONS SHOWING SUBSURFACE SOIL CONTAMINATION ABOVE GUIDELINES

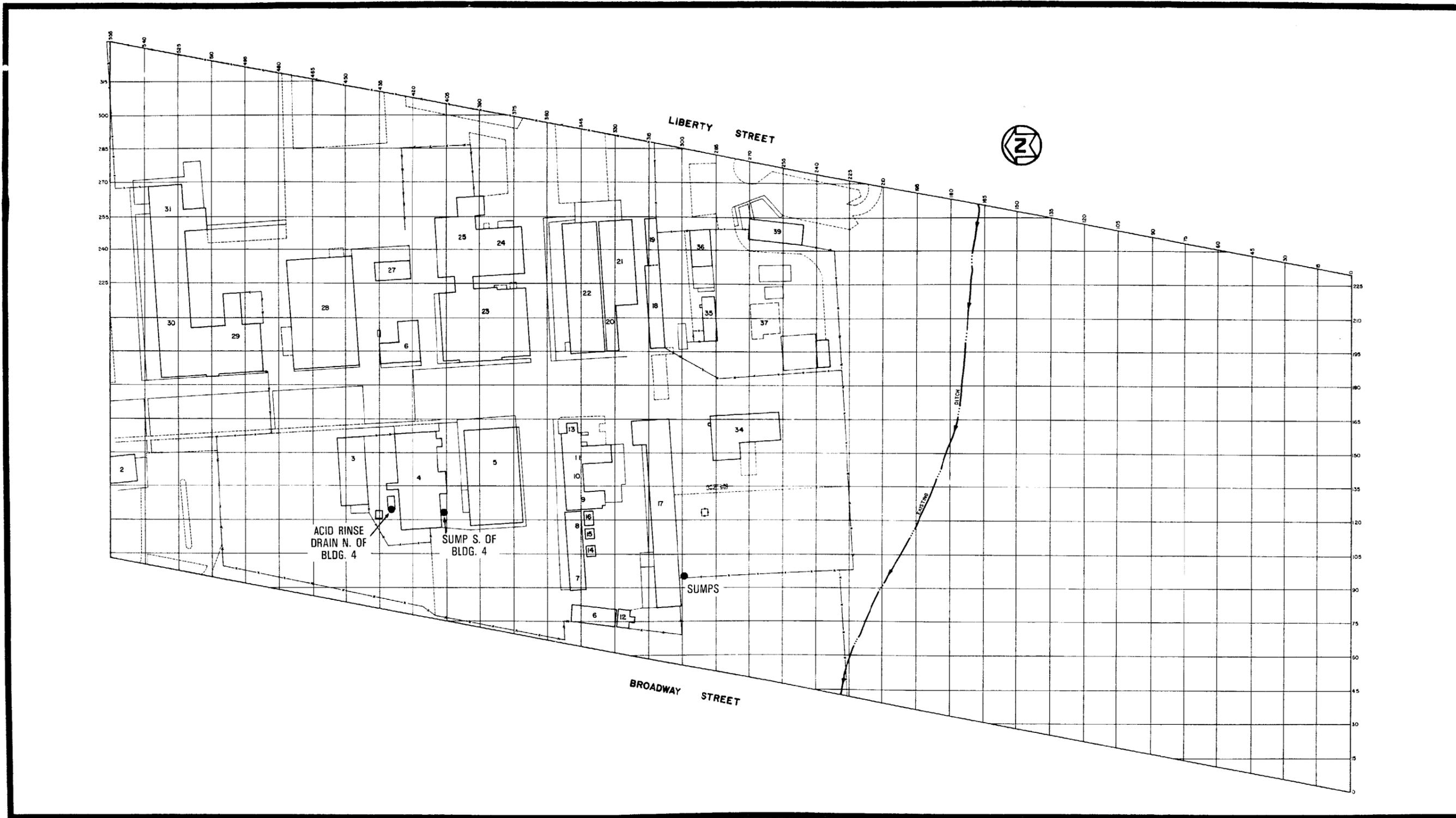
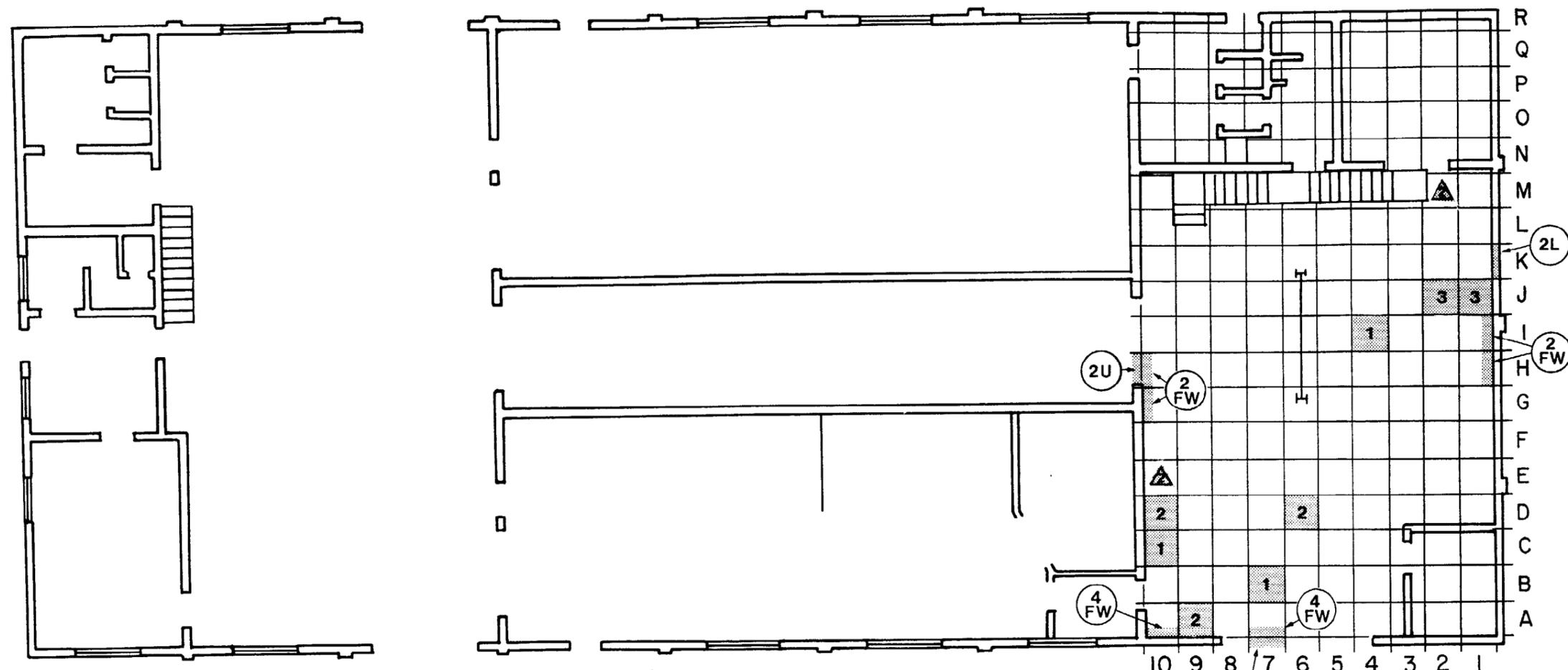


FIGURE 4-4 LOCATIONS SHOWING SEDIMENT CONTAMINATION ABOVE GUIDELINES



- CONTAMINATED AREA
- ▲ FILTER INLETS (IN RAFTERS)
- 1 - ABOVE-GUIDELINE SURFACE ALPHA CONTAMINATION
- 2 - ABOVE-GUIDELINE BETA-GAMMA DOSE RATES
- 3 - SURFACE ALPHA-CONTAMINATION AND BETA-GAMMA DOSE RATES ABOVE GUIDELINES
- 4 - ABOVE-GUIDELINE TRANSFERABLE ALPHA CONTAMINATION
- L - LOWER WALL
- U - UPPER WALL
- FW - FLOOR/WALL INTERSECTION

0 3
METERS

FIGURE 4-5 LOCATIONS OF ABOVE-GUIDELINE CONTAMINATION, BUILDING 4, OWL ROOM, FIRST LEVEL

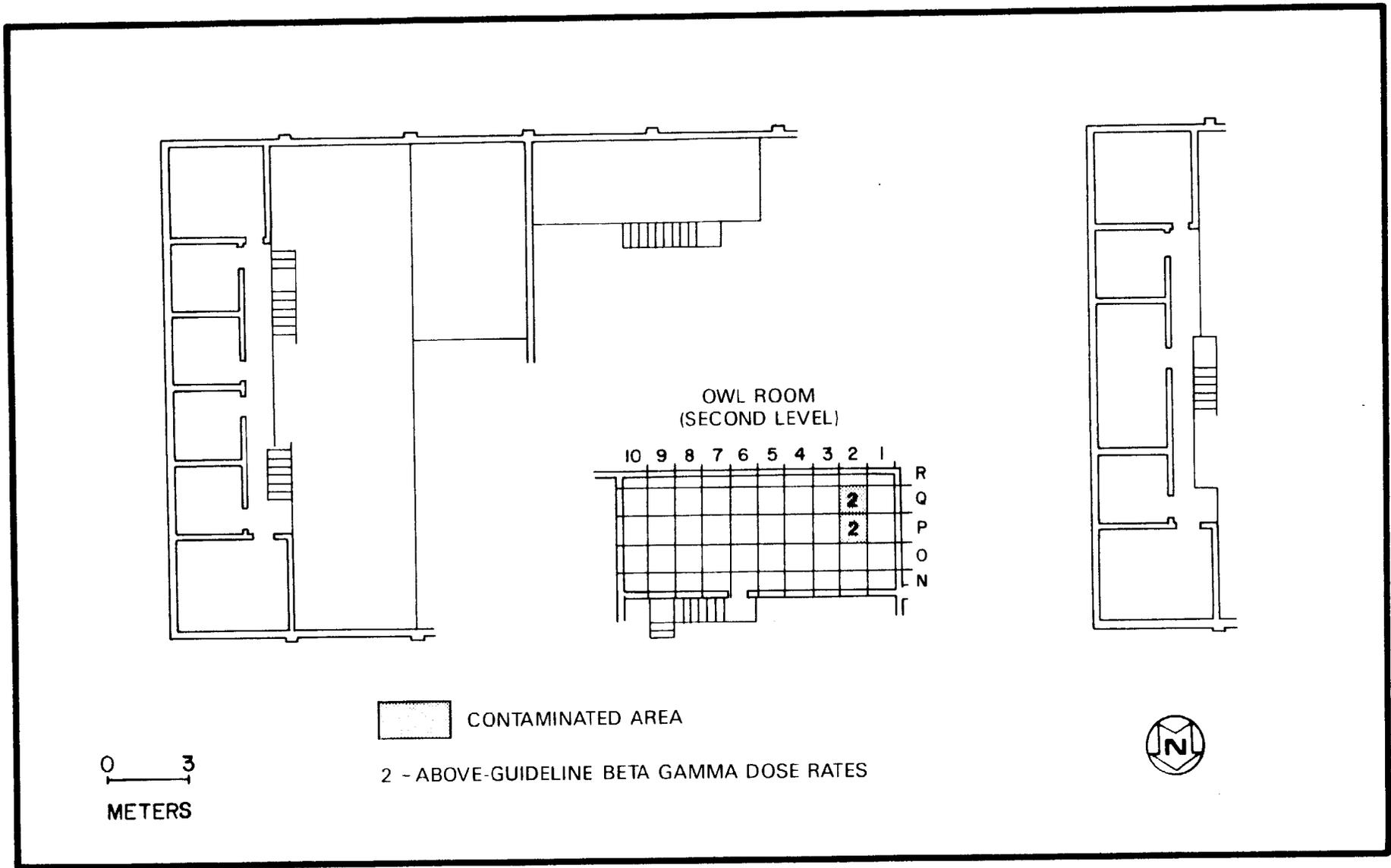


FIGURE 4-6 LOCATIONS OF ABOVE-GUIDELINE CONTAMINATION, BUILDING 4, OWL ROOM, SECOND LEVEL

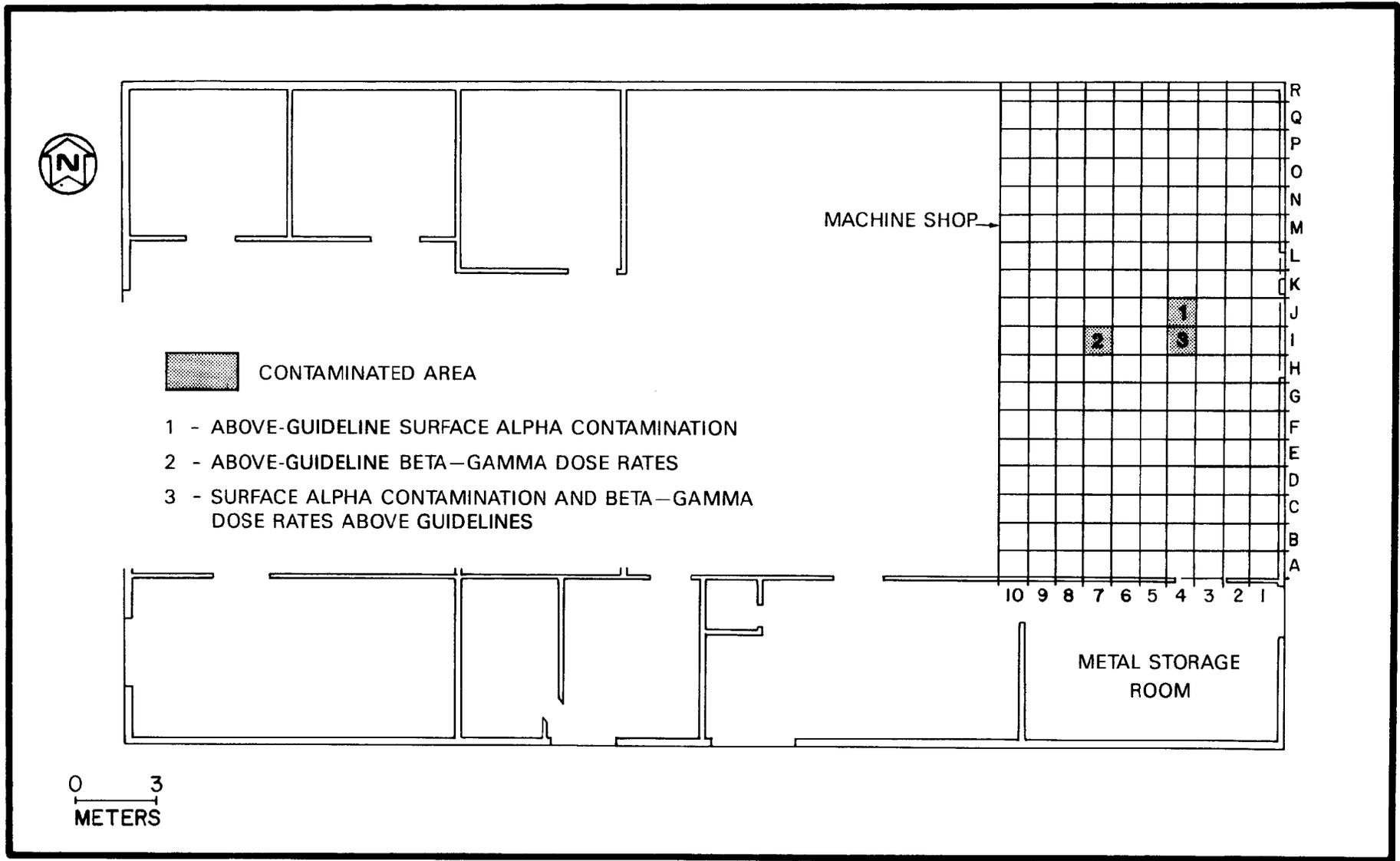


FIGURE 4-7 LOCATIONS OF ABOVE-GUIDELINE CONTAMINATION, BUILDING 5

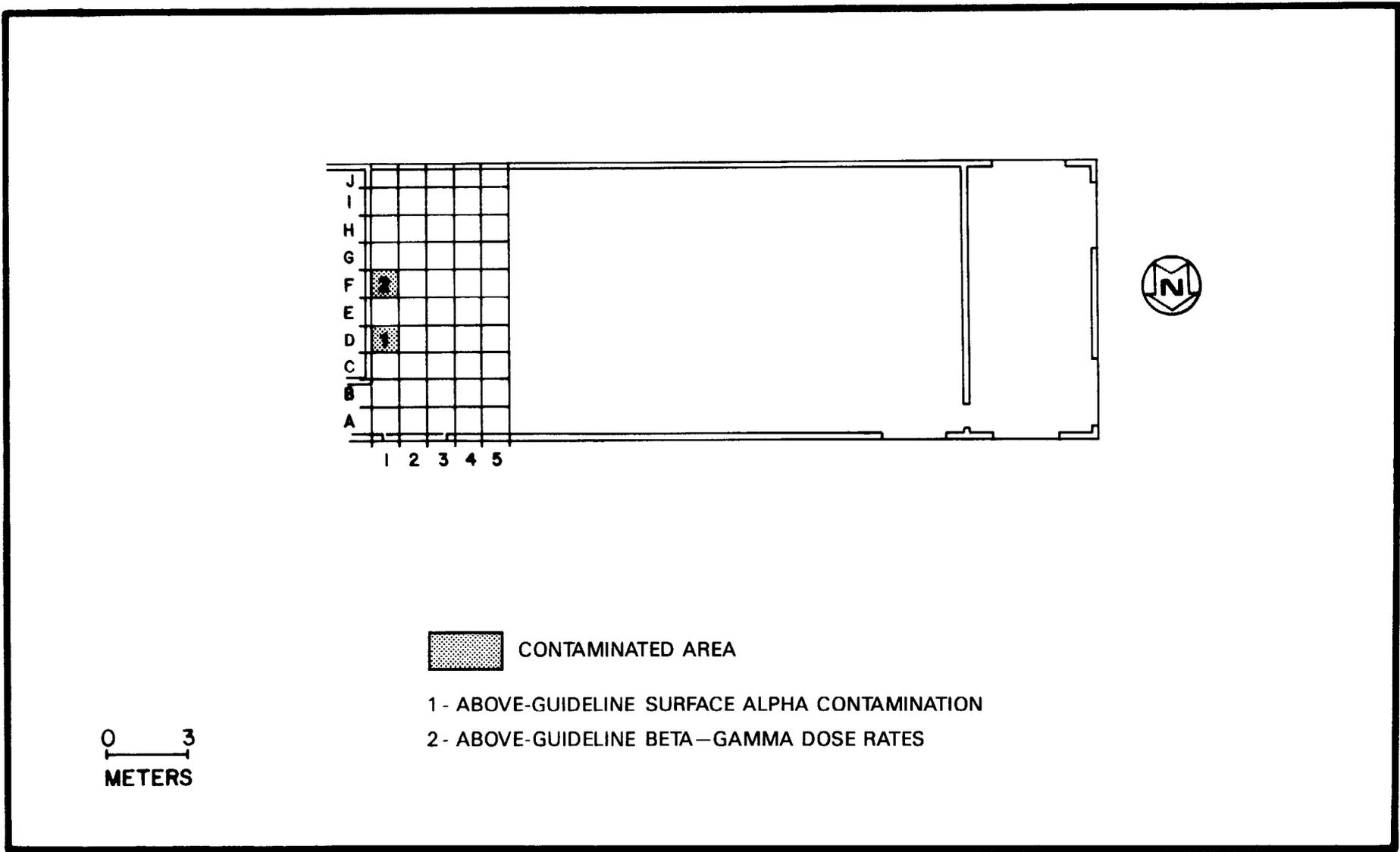


FIGURE 4-8 AREAS OF ABOVE-GUIDELINE CONTAMINATION, BUILDING 17, ROOM 10

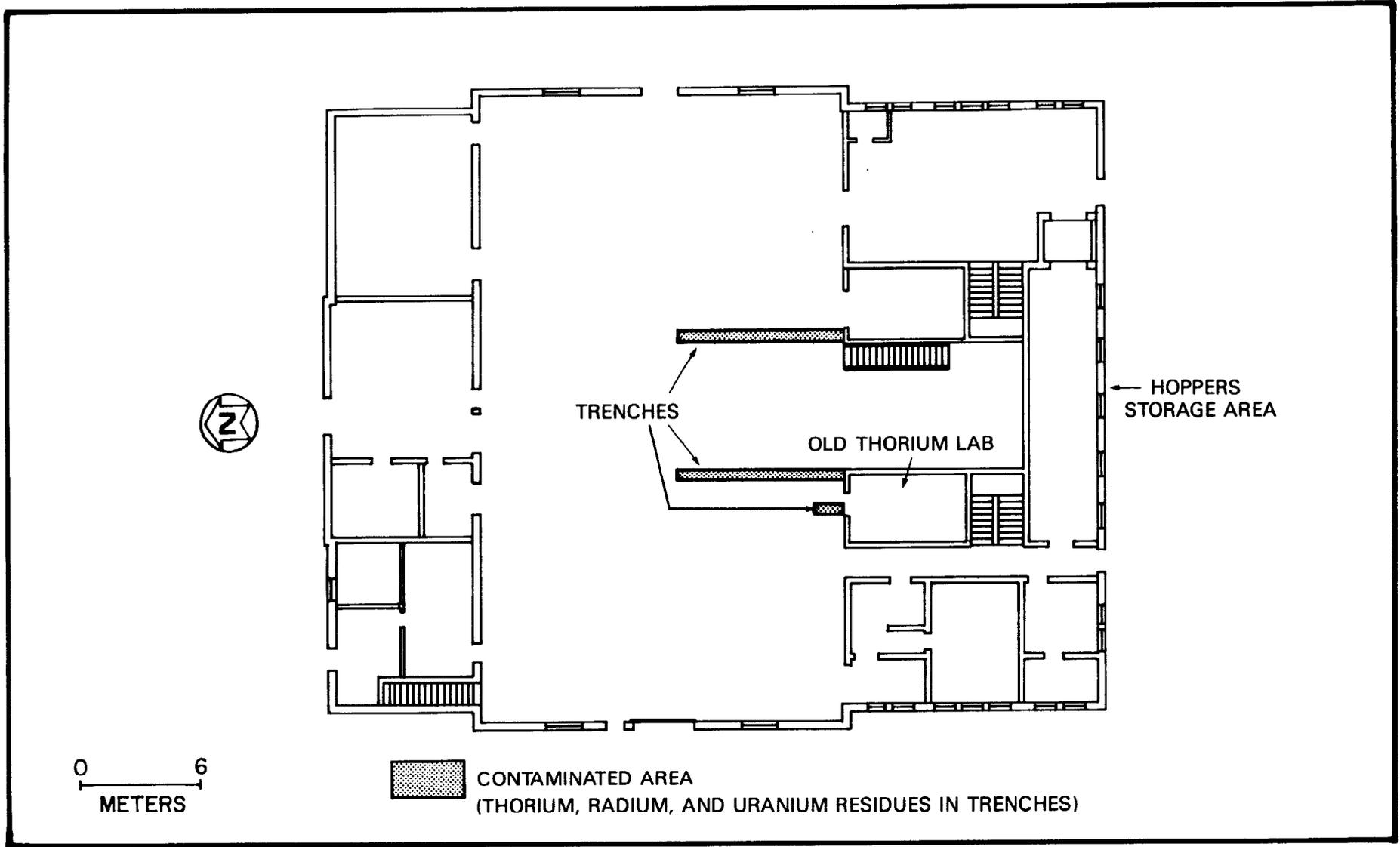


FIGURE 4-9 LOCATION OF CONTAMINATED AREAS, BUILDING 23

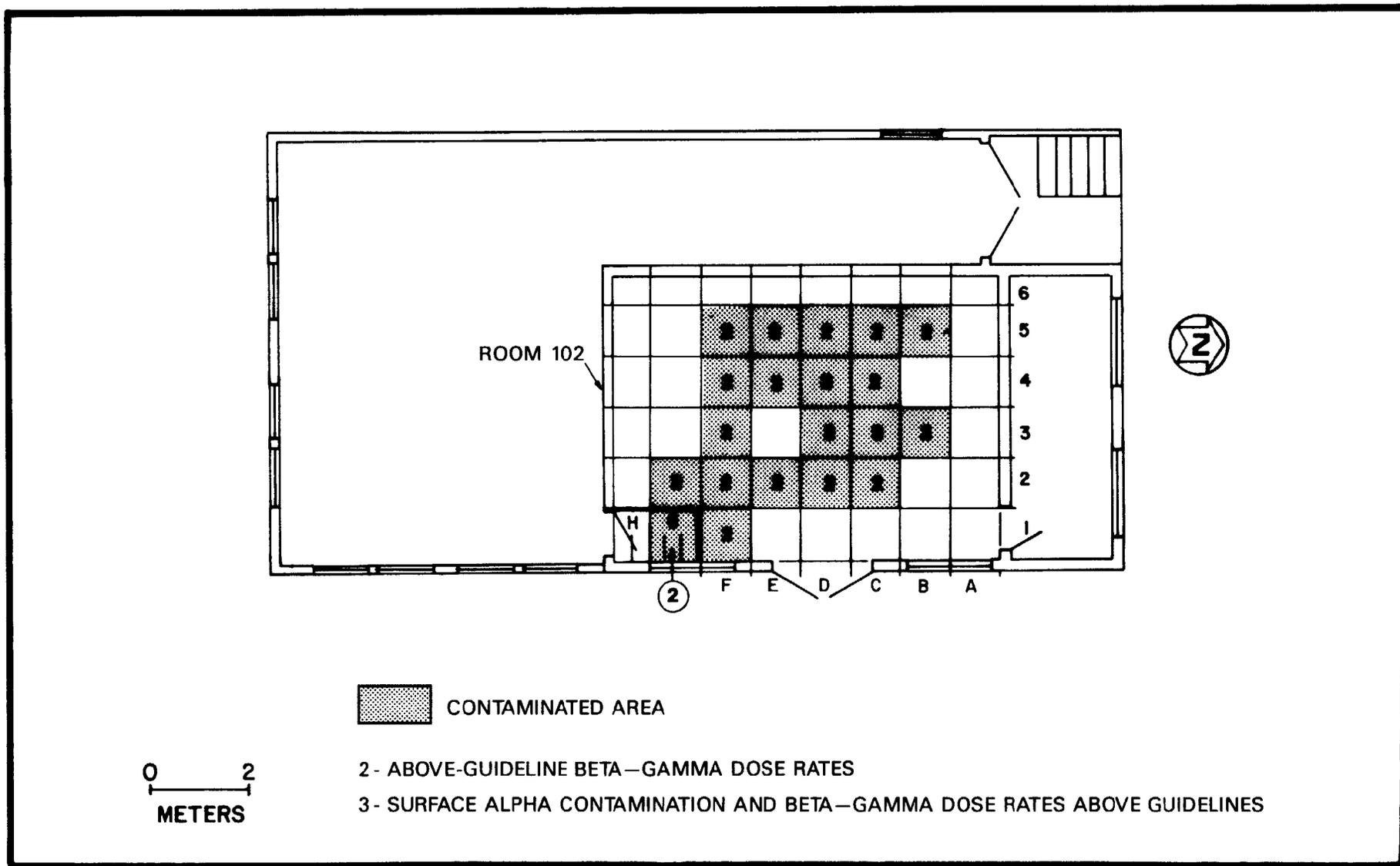


FIGURE 4-10 AREAS OF ABOVE-GUIDELINE CONTAMINATION, BUILDING 27, ROOM 102

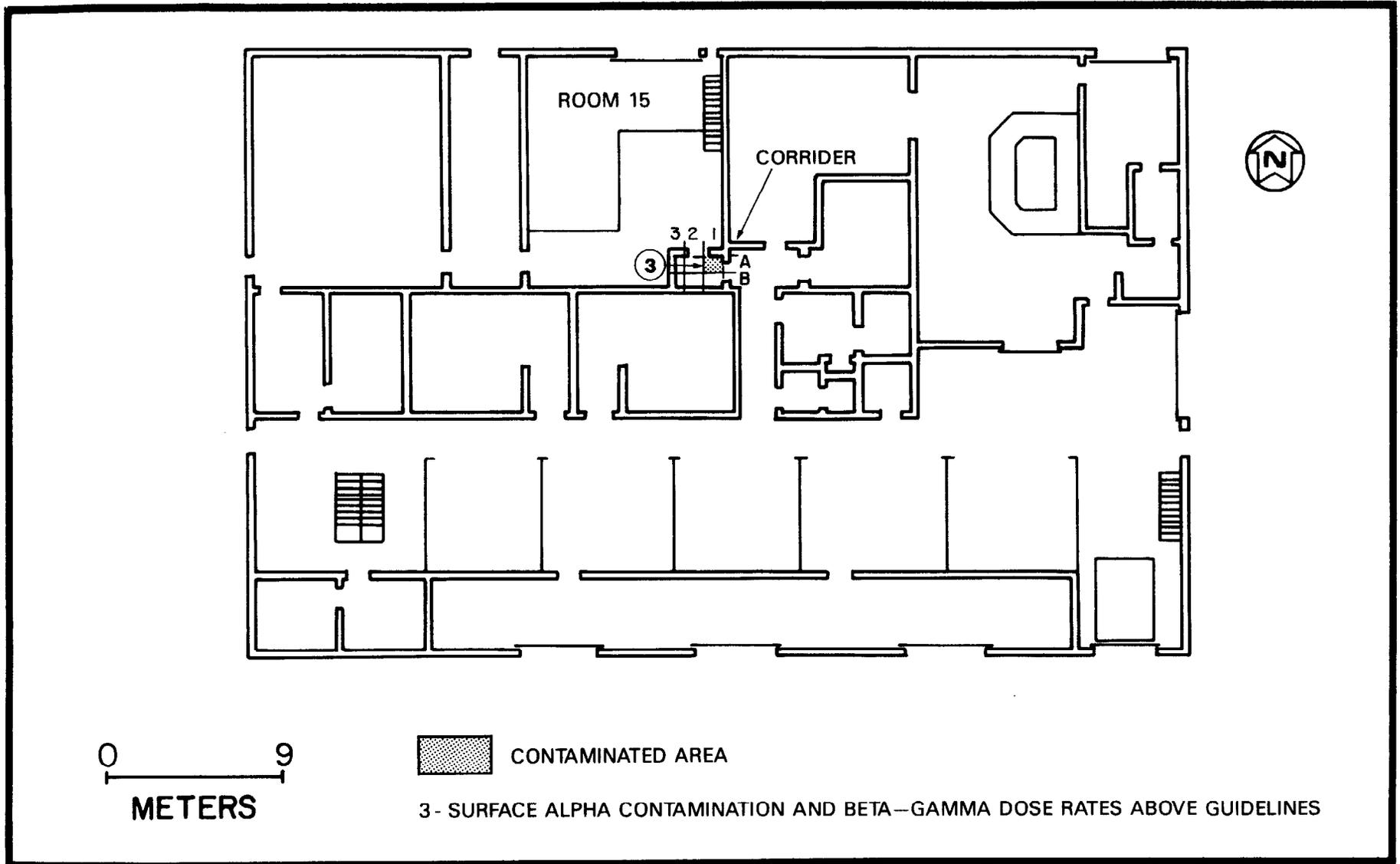


FIGURE 4-11 AREA OF ABOVE-GUIDELINE CONTAMINATION, BUILDING 28

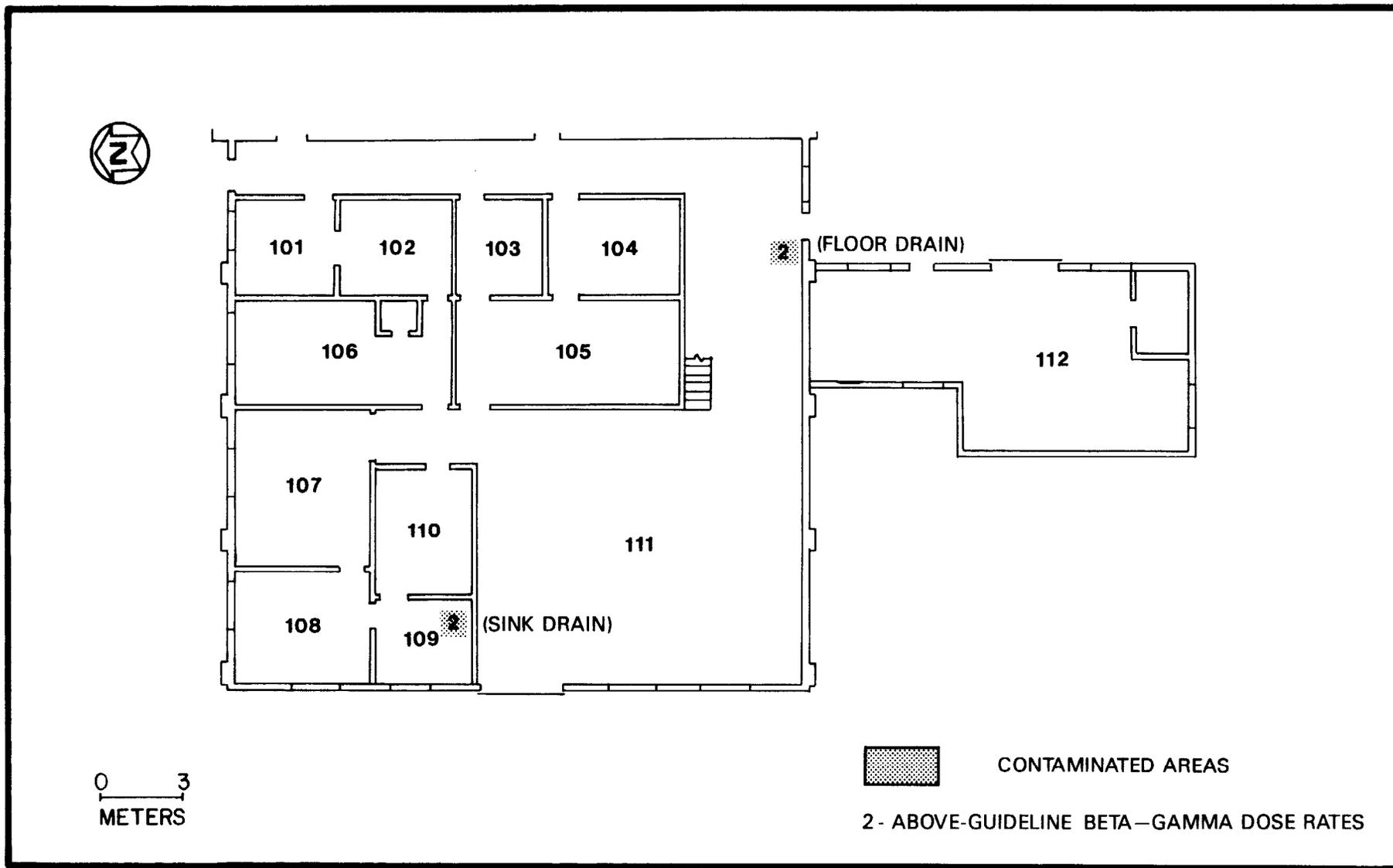


FIGURE 4-12 LOCATIONS OF ABOVE-GUIDELINE BETA-GAMMA CONTAMINATION, BUILDING 29

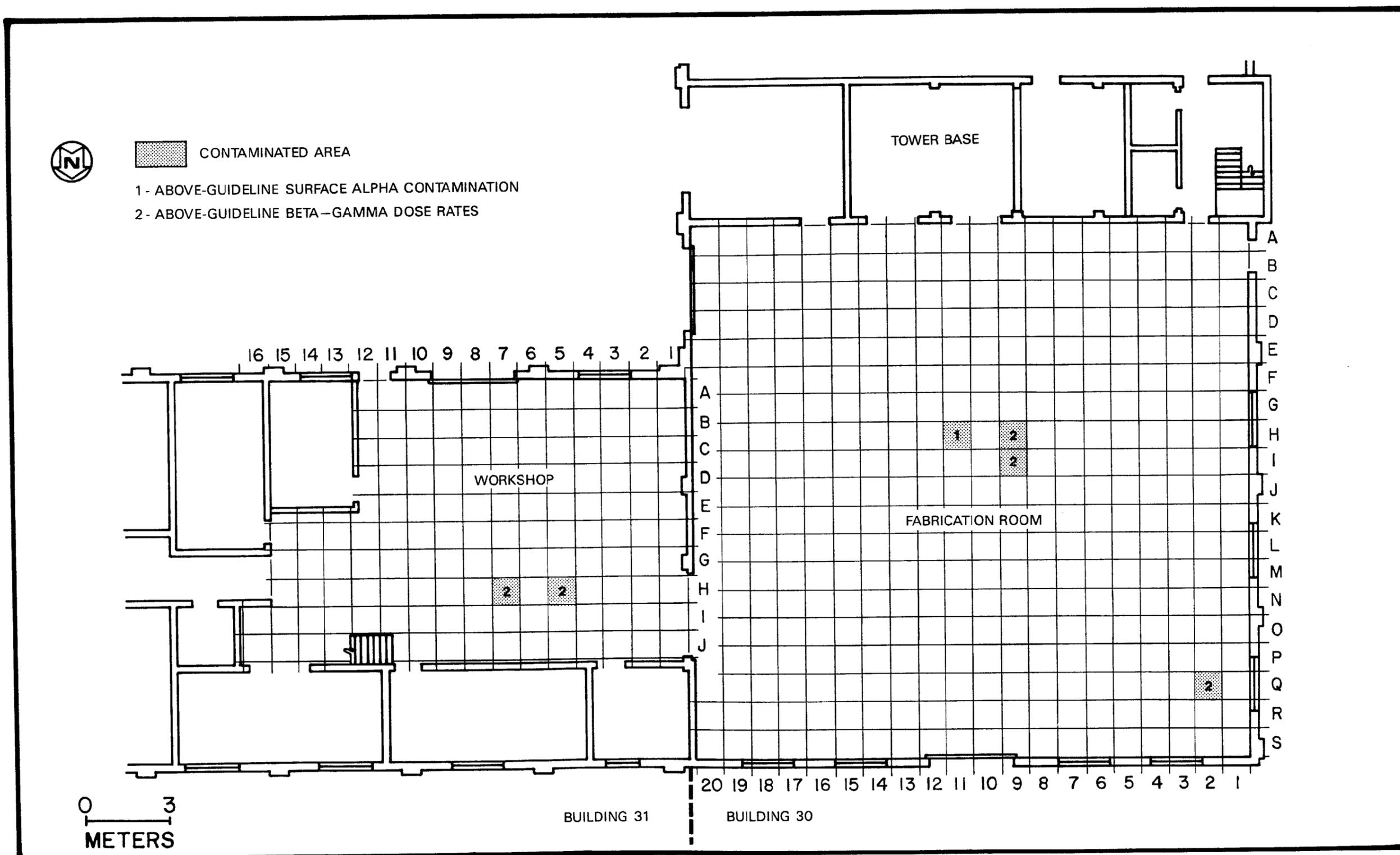


FIGURE 4-13 LOCATIONS OF ABOVE-GUIDELINE CONTAMINATION, BUILDING 30, FABRICATION ROOM, AND BUILDING 31, WORKSHOP

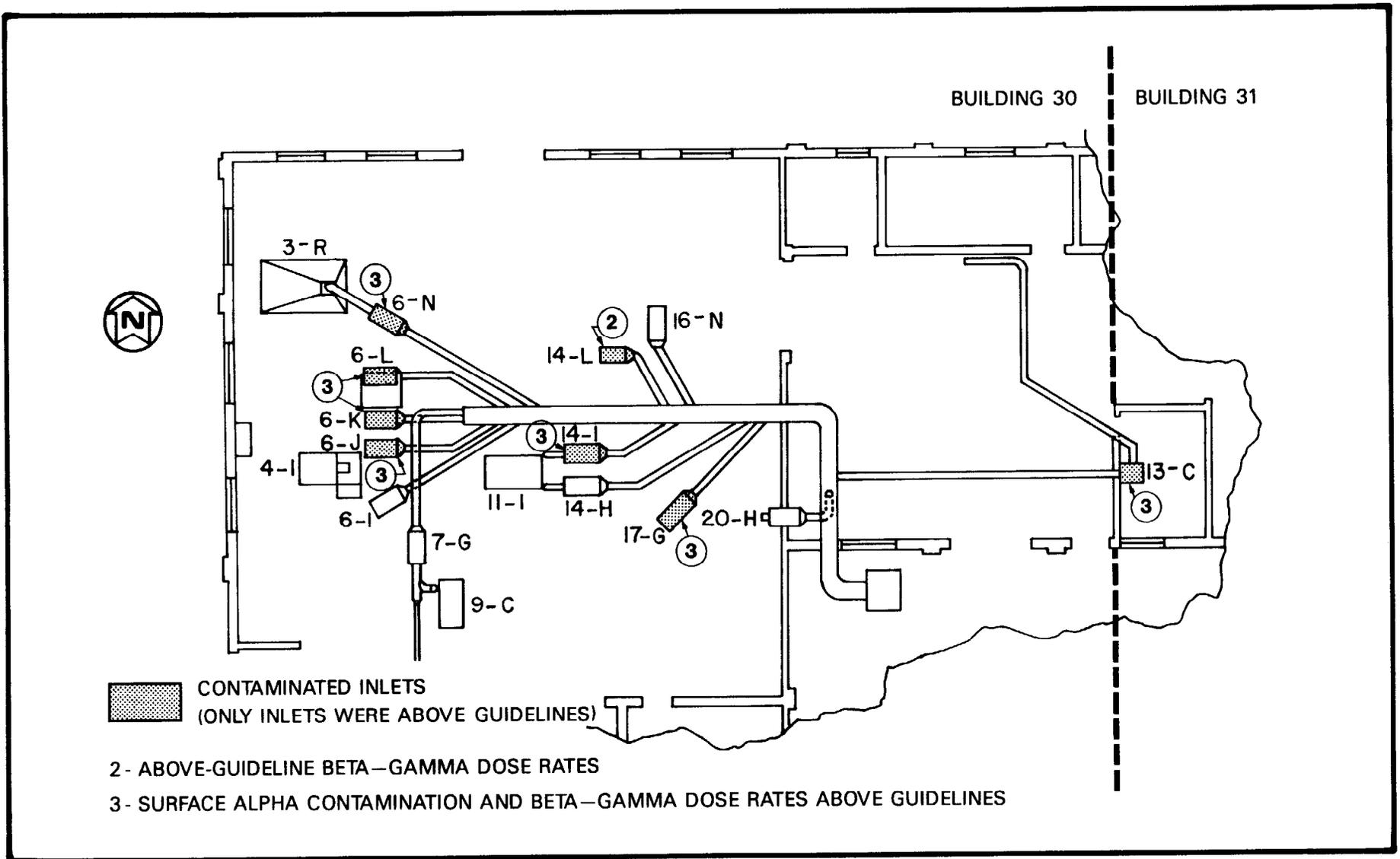


FIGURE 4-14 LOCATIONS OF ABOVE-GUIDELINE CONTAMINATION, FILTERING SYSTEM, BUILDINGS 30 AND 31

TABLE 4-1

BACKGROUND RADIATION MEASUREMENTS AND RADIONUCLIDE CONCENTRATIONS IN SOIL

Locations ^a	Gamma Exposure Rate at 1 m (μ R/h)	Gamma At 1 m (cpm)	Surface Beta-Gamma Dose Rates (mrad/h)	Near-Surface Gamma (cpm)	Radionuclide Concentrations (pCi/g)		
					U-238	Ra-226	Th-232
1	8.0	6203	0.03	636	b	1.0 \pm 0.5	1.2 \pm 0.4
2	7.9	6025	0.03	568	b	1.1 \pm 0.8	b
3	8.8	8060	0.02	699	b	2.7 \pm 0.8	b
4	9.1	8261	0.04	773	b	0.4 \pm 0.6	0.4 \pm 0.6
5	7.4	5224	0.03	598	b	1.2 \pm 0.5	b
6	6.1	4707	0.02	506	b	b	b
Averages	7.9	6413	0.03	630	b	1.3 \pm 0.6	0.8 \pm 0.5

^aBackground locations range from 500 to 3700 m from the ARC site.

^bConcentrations below the minimum detectable activity (MDA) are dependent on many variables (e.g., sample size, moisture content, other nuclide peaks present, etc.). Based on standard counting techniques, the MDA's for the ARC survey are: uranium-238, less than 1.0 pCi/g; radium-226, less than 0.4 pCi/g;; and thorium-232, less than 0.2 pCi/g.

TABLE 4-2
RESIDUAL CONTAMINATION GUIDELINES AND CRITERIA FOR FUSRAP SITES

Radionuclides in Soil and Sediment ^{a, b}	Guidelines
Uranium-238 ^c	150 pCi/g above background
Uranium-235 ^c	140 pCi/g above background
Uranium-234 ^c	150 pCi/g above background
Radium-226 and Thorium-232	5 pCi/g above background when averaged over the first 15 cm of soil below the surface; 15 pCi/g above background when averaged over 15-cm thick soil layers more than 15 cm below the surface

Radionuclides in Water	Criteria
Total Uranium	600 pCi/l
Radium-226	30 pCi/l
Thorium-232	2000 pCi/l

^aExcept for radium-226, these guidelines represent unrestricted-use concentrations above background, averaged across any 15-cm layer to any depth and over any contiguous 100-m² surface area. The same conditions prevail for radium-226. Beneath 1.5 m, the allowable radium-226 concentration may be affected by site-specific conditions and must be evaluated accordingly.

^bLocalized concentrations in excess of these limits are allowable provided that the average over 100 m² is not exceeded.

^cAssumes that no other uranium isotopes are present.

Source: DOE (Refs. 5 and 6)

TABLE 4-3
ALBANY RESEARCH CENTER: PRE-REMEDIAL ACTION SUMMARY
OF OUTDOOR MEASUREMENT RESULTS

Measurement Type ^a	Units	Number of Measurements Made	Range	Normal Background (BKG) ^b
Near-Surface Gamma	cpm	8000	524 - 68,942	630
Gamma at 1 m	cpm	200	5,524 - 21,024 ^(c)	6,413
Beta-Gamma Dose Rates	mrad/h	8000	BKG - 1.9	0.03
Gamma Exposure Rates	uR/h	15	7.8 - 17.0	7.9

^aNear-surface and 1-m gamma measurements were made with a SPA-3 coupled with a PRS-1. Beta-gamma dose rates were measured with an HP-210 and PRS-1. Gamma exposure rates were measured with a PIC.

^bBackground measured during 1984 survey.

^cThese count rates correspond to the equivalent gamma exposure rate of 5.8 to 22.2 uR/h.

TABLE 4-4
ALBANY RESEARCH CENTER: GAMMA SPECTROMETRY
ANALYSIS OF SURFACE SOIL SAMPLES^a

Page 1 of 6

Sampling Location		Depth (inches)	Radionuclide Concentrations (pCi/g +/- 2 Sigma)		
Grid E	Grid N		Uranium-238	Radium-226	Thorium-232
0	270	0-6	b	1.8 + 0.5	0.4 + 0.9
30	45	0-6	b	1.2 + 0.2	0.7 + 0.2
30	105	0-6	b	1.0 + 0.2	b
45	15	0-6	b	1.1 + 0.2	0.8 + 0.2
60	75	0-6	b	1.3 + 0.5	1.4 + 0.4
60	135	0-6	b	10.0 + 2.1	1.6 + 1.5
60	210	0-6	b	2.0 + 0.4	1.0 + 0.2
60	225	0-6	6.3 + 2.6	2.6 + 0.5	b
60	240	0-6	b	1.4 + 0.2	b
60	255	0-6	b	2.0 + 0.4	1.4 + 0.4
60	270	0-6	b	1.6 + 0.8	1.2 + 0.2
60	285	0-6	b	1.2 + 0.4	0.6 + 0.2
60	300	0-6	b	0.9 + 0.5	1.0 + 0.3
60	315	0-6	b	0.8 + 0.2	b
60	330	0-6	b	0.8 + 0.3	b
69	302	0-6	b	3.6 + 1.3	84.8 + 2.7
69	302	0 ^c	b	2.3 + 0.3	5.1 + 0.8
75	210	0-6	b	1.2 + 0.4	1.4 + 0.2
75	225	0-6	b	0.8 + 0.6	b
75	240	0-6	b	0.7 + 0.3	0.9 + 0.4
75	255	0-6	b	2.0 + 0.4	0.8 + 0.4
75	285	0-6	b	1.6 + 0.4	1.0 + 0.2
75	292	0-6	b	1.0 + 0.7	1.8 + 0.6
75	292	0 ^c	b	1.1 + 0.7	b
75	300	0-6	b	0.8 + 0.4	1.0 + 0.2
75	330	0-6	b	1.0 + 0.2	1.3 + 0.2
75	351	0-6	2.5 + 1.5	1.1 + 0.2	0.6 + 0.2
90	105	0-6	b	1.1 + 0.3	0.5 + 0.2
90	210	0-6	b	0.7 + 0.2	0.3 + 0.1
90	225	0-6	b	2.0 + 0.4	0.4 + 0.2
90	255	0-6	b	1.6 + 0.4	0.8 + 0.2
90	270	0-6	b	2.0 + 0.5	0.6 + 0.2
90	285	0-6	b	2.4 + 0.5	b
90	300	0-6	b	0.8 + 0.4	1.4 + 0.2
92	290	0-6	b	1.2 + 0.6	8.9 + 1.3
92	290	0 ^c	12.2 + 7.3	1.2 + 0.6	11.4 + 1.3
93	295	0-6	b	1.7 + 1.2	10.7 + 1.4
93	295	0 ^c	b	1.6 + 0.6	1.0 + 0.5
95	295	0-6	b	1.0 + 0.2	0.5 + 0.2
95	297	0-6	b	0.9 + 0.3	1.9 + 0.3
97	295	0-6	b	1.0 + 0.2	1.1 + 0.2
100	297	0-6	b	0.9 + 0.3	3.8 + 0.4
105	45	0-6	b	1.0 + 0.3	0.4 + 0.2

TABLE 4-4
(continued)

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Sampling Location		Depth (inches)	Radionuclide Concentrations (pCi/g +/- 2 Sigma)		
Grid E	Grid N		Uranium-238	Radium-226	Thorium-232
105	195	0-6	b	1.0 + 0.3	
105	210	0-6	b	1.0 + 0.3	0.4 + 0.1
105	255	0-6	b	1.6 + 0.4	2.0 + 0.4
105	270	0-6	b	2.0 + 0.8	0.8 + 0.2
105	282	0-6	b	b	30.1 + 1.2
105	285	0-6	b	2.3 + 0.5	2.7 + 0.7
105	300	0-6	11.5 + 3.8	1.1 + 0.3	3.9 + 0.7
105	420	0-6	b	0.7 + 0.3	0.6 + 0.3
105	435	0-6	b	0.8 + 0.4	1.0 + 0.2
105	450	0-6	b	0.6 + 0.2	b
105	465	0-6	b	0.8 + 0.3	0.5 + 0.2
106	205	0-6	b	0.8 + 0.2	0.3 + 0.2
107	285	0-6	b	1.0 + 0.2	1.3 + 0.3
110	282	0-6	b	1.3 + 0.5	1.2 + 0.3
110	287	0-6	b	2.0 + 0.6	14.2 + 1.0
113	184	0-6	b	1.2 + 0.2	0.6 + 0.2
115	447	0-6	b	b	23.4 + 1.4
117	425	0-6	b	2.0 + 0.3	2.0 + 0.6
117	427	0-6	b	0.7 + 0.3	6.3 + 0.7
117	430	0-6	b	b	6.3 + 0.7
117	432	0-6	b	1.3 + 0.4	8.4 + 0.8
117	435	0-6	b	b	7.0 + 0.8
117	437	0-6	b	1.9 + 0.5	12.6 + 0.8
117	440	0-6	b	b	62.3 + 1.8
117	442	0-6	21.1 + 8.6	0.9 + 0.7	59.8 + 1.6
117	445	0-6	4.6 + 4.1	0.7 + 0.4	16.7 + 0.8
117	447	0-6	b	1.2 + 0.3	3.8 + 0.4
120	30	0-6	b	0.5 + 0.2	0.2 + 0.3
120	195	0-6	2.5 + 1.4	0.5 + 0.3	b
120	210	0-6	b	2.1 + 0.5	b
120	255	0-6	b	2.0 + 0.8	1.2 + 0.2
120	270	0-6	b	1.0 + 0.3	b
120	285	0-6	b	2.0 + 0.8	1.4 + 0.4
120	300	0-6	b	1.6 + 0.8	0.8 + 0.2
120	427	0-6	5.4 + 4.0	b	10.9 + 0.8
120	430	0-6	b	b	8.7 + 0.8
120	432	0-6	b	1.9 + 0.5	10.7 + 0.9
120	435	0-6	b	b	15.0 + 1.2
120	437	0-6	13.0 + 5.5	1.1 + 0.6	20.6 + 1.3
120	440	0-6	b	b	2.8 + 0.4
120	442	0-6	b	1.2 + 0.4	2.6 + 0.4
120	450	0-6	b	2.0 + 0.8	28.0 + 2.0
120	465	0-6	b	0.4 + 0.2	b
120	480	0-6	b	0.5 + 0.1	b

TABLE 4-4
(continued)

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Sampling Location		Depth (inches)	Radionuclide Concentrations (pCi/g +/- 2 Sigma)		
Grid E	Grid N		Uranium-238	Radium-226	Thorium-232
135	105	0-6	2.1 + 1.3	1.0 + 0.3	0.8 + 0.2
135	165	0-6	b	1.2 + 0.8	0.6 + 0.2
135	180	0-6	b	0.7 + 0.2	b
135	195	0-6	b	0.8 + 0.3	b
135	210	0-6	b	1.8 + 0.7	1.0 + 0.5
135	225	0-6	b	1.2 + 0.4	0.8 + 0.2
135	465	0-6	b	1.4 + 0.2	b
135	480	0-6	b	b	0.6 + 0.2
150	45	0-6	1.3 + 1.6	0.6 + 0.2	0.4 + 0.3
150	165	0-6	b	1.6 + 0.4	0.8 + 0.2
150	180	0-6	b	1.2 + 0.8	1.0 + 0.2
150	195	0-6	b	1.0 + 0.3	0.4 + 0.2
150	210	0-6	b	1.6 + 0.6	0.8 + 0.5
150	225	0-6	b	1.6 + 0.4	0.8 + 0.2
150	465	0-6	b	0.5 + 0.2	b
150	480	0-6	b	0.4 + 0.3	b
162	395	0-6	b	b	30.7 + 1.3
165	15	0-6	b	2.1 + 0.5	0.8 + 0.5
165	165	0-6	b	2.6 + 0.5	0.4 + 0.4
165	180	0-6	b	1.6 + 0.8	1.0 + 0.2
165	195	0-6	b	0.8 + 0.2	b
165	210	0-6	b	0.9 + 0.5	b
165	225	0-6	b	1.3 + 0.6	b
173	442	0-6	b	2.4 + 0.6	10.0 + 1.0
180	75	0-6	b	1.8 + 0.6	1.4 + 0.6
180	165	0-6	b	1.6 + 0.4	1.4 + 0.2
180	180	0-6	b	1.2 + 0.8	0.4 + 0.2
180	195	0-6	b	1.2 + 0.8	1.0 + 0.4
180	210	0-6	b	2.3 + 0.7	1.1 + 0.6
180	222	0-6	37.5 + 9.3	50.5 + 2.2	b
180	225	0-6	19.5 + 8.2	32.2 + 1.8	1.8 + 0.6
182	220	0-6	10.0 + 2.0	48.0 + 4.0	0.8 + 0.4
182	222	0-6	14.0 + 4.0	56.0 + 4.0	1.0 + 0.4
185	217	0-6	b	4.0 + 0.8	2.0 + 0.4
185	220	0-6	6.9 + 6.1	20.3 + 1.4	1.3 + 0.4
192	212	0-6	b	20.0 + 2.0	1.6 + 0.4
195	45	0-6	b	1.1 + 0.2	0.6 + 0.2
195	165	0-6	b	1.6 + 0.8	1.0 + 0.2
195	180	0-6	b	1.2 + 0.8	1.4 + 0.4
195	195	0-6	b	1.2 + 0.3	0.9 + 0.3
195	210	0-6	b	12.0 + 2.0	1.2 + 0.4
195	225	0-6	b	3.7 + 0.7	1.5 + 0.5
200	190	0-6	3.3 + 3.4	14.1 + 0.8	1.0 + 0.3
200	197	0-6	b	5.2 + 0.8	1.0 + 0.4
200	205	0-6	b	3.3 + 0.4	1.5 + 0.2

TABLE 4-4
(continued)

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Sampling Location		Depth (inches)	Radionuclide Concentrations (pCi/g +/- 2 Sigma)		
Grid E	Grid N		Uranium-238	Radium-226	Thorium-232
202	177	0-6	11.0 + 3.0	56.0 + 4.0	1.4 + 0.4
202	187	0-6	14.0 + 4.0	48.0 + 4.0	b
202	190	0-6	13.0 + 4.0	68.0 + 8.0	b
202	192	0-6	13.0 + 4.0	52.0 + 4.0	b
202	195	0-6	b	32.0 + 2.0	b
202	200	0-6	b	8.0 + 2.0	2.0 + 0.4
202	202	0-6	b	10.3 + 0.7	b
202	207	0-6	b	1.8 + 0.3	1.7 + 0.3
205	187	0-6	b	28.0 + 2.0	2.6 + 0.4
205	190	0-6	b	34.0 + 2.0	0.6 + 0.4
205	192	0-6	9.0 + 3.0	38.0 + 2.0	3.0 + 0.6
205	195	0-6	b	4.8 + 0.5	b
205	197	0-6	b	1.6 + 0.3	0.4 + 0.3
205	200	0-6	b	28.0 + 2.0	0.8 + 0.4
206	475	0-6	b	b	1.6 + 0.3
207	187	0-6	4.9 + 4.1	29.5 + 1.1	b
210	105	0-6	2.0 + 1.1	0.5 + 0.3	0.8 + 0.2
210	165	0-6	b	2.0 + 0.4	0.8 + 0.2
210	180	0-6	b	1.1 + 0.2	0.6 + 0.2
210	187	0-6	b	22.0 + 2.0	1.2 + 0.4
210	195	0-6	b	7.1 + 0.5	1.1 + 0.3
210	210	0-6	b	7.2 + 0.9	3.0 + 0.5
210	225	0-6	b	3.6 + 0.8	3.0 + 0.4
210	300	0-6	b	1.0 + 0.5	1.5 + 0.4
210	284	2-6	b	1.3 + 0.4	0.3 + 0.2
211	475	0-6	20.6 + 4.8	0.6 + 0.5	10.0 + 0.9
215	182	0-6	b	2.0 + 0.8	4.0 + 0.4
217	182	0-6	b	8.0 + 2.0	20.0 + 2.0
225	45	0-6	b	1.2 + 0.4	0.6 + 0.4
225	165	0-6	b	0.6 + 0.4	0.5 + 0.1
225	180	0-6	b	b	5.2 + 0.6
225	182	0-6	b	1.0 + 0.3	1.3 + 0.3
225	195	0-6	b	1.0 + 0.4	b
225	200	0-6	b	1.6 + 0.4	2.2 + 0.4
225	210	0-6	b	2.4 + 0.8	2.8 + 0.4
225	225	0-6	9.2 + 4.8	5.1 + 1.0	4.9 + 0.8
225	300	0-6	b	1.3 + 0.5	1.5 + 0.5
227	190	0-6	b	2.8 + 0.6	b
230	185	0-6	b	2.7 + 0.7	5.1 + 0.8
230	257	0-6	b	5.4 + 1.4	71.3 + 3.3
232	185	0-6	b	2.0 + 0.8	3.6 + 0.6
235	185	0-6	b	6.8 + 1.2	22.0 + 2.0
236	495	0-6	b	0.4 + 0.2	1.0 + 0.2
236	505	0-6	b	0.9 + 0.2	0.6 + 0.2
240	105	0-6	b	1.1 + 0.3	0.6 + 0.2

TABLE 4-4
(continued)

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Sampling Location		Depthn (inches)	Radionuclide Concentrations (pCi/g +/- 2 Sigma)		
Grid E	Grid N		Uranium-238	Radium-226	Thorium-232
240	165	0-6	o	1.2 + 0.4	0.8 + 0.2
240	180	0-6	o	1.6 + 0.4	1.0 + 0.2
240	195	0-6	o	1.6 + 0.3	2.1 + 0.3
240	210	0-6	o	1.7 + 0.6	1.4 + 0.4
240	225	0-6	b	5.6 + 0.8	3.0 + 0.7
240	240	0-6	b	0.5 + 0.3	o
240	255	0-6	b	2.6 + 0.5	1.8 + 0.6
240	270	0-6	b	1.7 + 0.7	o
240	300	0-6	o	1.9 + 0.5	0.8 + 0.3
242	307	0-6	o	2.0 + 0.8	1.4 + 0.4
242	310	0-6	o	0.8 + 0.2	1.2 + 0.2
245	305	0-6	b	1.2 + 0.2	1.2 + 0.3
245	307	0-6	b	1.6 + 0.4	1.2 + 0.4
245	310	0-6	b	1.2 + 0.4	1.4 + 0.2
245	480	0-6	o	0.6 + 0.3	2.7 + 0.4
245	482	0-6	b	1.3 + 0.4	1.3 + 0.3
247	302	0-6	b	2.8 + 0.4	3.0 + 0.4
247	305	0-6	b	1.6 + 0.8	1.4 + 0.4
247	307	0-6	b	1.1 + 0.2	0.6 + 0.2
247	310	0-6	b	1.4 + 0.2	0.7 + 0.2
250	290	0-6	b	3.0 + 0.8	4.1 + 1.0
250	292	0-6	o	3.3 + 0.7	2.2 + 1.5
250	305	0-6	o	1.6 + 0.8	1.4 + 0.2
250	307	0-6	o	0.9 + 0.2	0.6 + 0.1
250	310	0-6	o	1.6 + 0.8	1.6 + 0.4
252	307	0-6	b	1.1 + 0.2	0.5 + 0.2
252	295	0-6	o	2.4 + 0.8	4.6 + 0.6
252	305	0-6	b	b	1.6 + 0.3
252	310	0-6	b	b	1.2 + 0.4
255	165	0-6	b	2.0 + 0.8	1.8 + 0.4
255	180	0-6	b	1.2 + 0.4	0.4 + 0.2
255	195	0-6	b	0.8 + 0.3	o
255	210	0-6	o	1.2 + 0.4	1.0 + 0.2
255	255	0-6	b	1.2 + 0.4	1.0 + 0.2
255	270	0-6	b	1.6 + 0.4	0.8 + 0.2
255	285	0-6	o	2.8 + 0.8	0.6 + 0.2
255	300	0-6	o	2.8 + 0.8	2.6 + 0.4
255	305	0-6	o	2.4 + 0.8	2.8 + 0.4
255	307	0-6	o	1.2 + 0.4	2.4 + 0.4
255	310	0-6	b	5.5 + 0.5	0.9 + 0.2
255	480	0-6	o	0.9 + 0.2	0.2 + 0.2
255	495	0-6	b	0.9 + 0.2	0.2 + 0.1
257	305	0-6	o	2.4 + 0.8	2.2 + 0.4
257	350	0-6	o	1.1 + 0.3	3.3 + 0.4
260	350	0-6	o	1.6 + 0.8	1.4 + 0.4

TABLE 4-4
(continued)

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Sampling Location		Depth (inches)	Radionuclide Concentrations (pCi/g +/- 2 Sigma)		
Grid E	Grid N		Uranium-238	Radium-226	Thorium-232
260	365	0-6	b	1.2 + 0.3	1.7 + 0.3
260	512	0-6	b	0.4 + 0.3	5.6 + 0.6
262	307	0-6	b	0.4 + 0.2	1.5 + 0.3
262	352	0-6	b	0.8 + 0.3	3.7 + 0.4
262	512	0-6	5.1 + 4.3	b	17.7 + 0.9
265	512	0-6	b	b	13.3 + 0.3
267	512	0-6	b	b	18.5 + 1.0
270	225	0-6	b	1.0 + 0.4	0.6 + 0.3
270	270	0-6	b	2.0 + 0.8	0.8 + 0.2
270	300	0-6	3.6 + 1.7	2.8 + 3.3	0.6 + 0.2
270	345	0-6	b	b	0.5 + 0.2
270	390	0-6	b	1.3 + 0.3	b
270	510	0-6	b	0.5 + 0.2	1.5 + 0.3
270	512	0-6	b	b	41.9 + 1.5
272	512	0-6	b	0.6 + 0.2	4.3 + 0.4
275	512	0-6	b	b	12.3 + 0.6
280	532	0-6	b	b	12.4 + 1.1
280	535	0-6	b	b	10.2 + 0.6
280	537	0-6	b	0.8 + 0.3	5.7 + 0.6
282	527	0-6	b	0.7 + 0.3	7.0 + 0.6
282	530	0-6	b	b	3.7 + 0.5
282	532	0-6	b	b	6.1 + 0.5
282	535	0-6	b	0.5 + 0.3	3.4 + 0.5
285	300	0-6	b	2.2 + 0.4	b
285	390	0-6	b	1.2 + 0.3	0.3 + 0.4
285	510	0-6	b	1.2 + 0.3	0.6 + 0.3
285	525	0-6	b	b	1.0 + 0.3
285	540	0-6	b	1.1 + 0.2	b
300	525	0-6	b	1.6 + 0.4	0.6 + 0.2
300	540	0-6	b	1.1 + 0.3	b
312	482	0-6	b	0.4 + 0.3	1.2 + 0.3

^aSampling locations are shown in Figure 3-4.

^bConcentrations below the minimum detectable activity (MDA) are dependent on many variables (e.g., sample size, moisture content, other nuclide peaks present, etc.). Based on standard counting techniques, the MDA's are: uranium-238, less than 1.0 pCi/g; radium-226, less than 0.4 pCi/g; and thorium-232, less than 0.2 pCi/g.

^cSamples were taken from the spoils surrounding a borehole.

TABLE 4-5
 ALBANY RESEARCH CENTER: GAMMA SPECTROMETRY
 ANALYSIS OF SUBSURFACE SOIL SAMPLES^a

Page 1 of 2

Sampling Location		Depthn (inches)	Radionuclide Concentrations (pCi/g +/- 2 Sigma)		
Grid E	Grid N		Uranium-238	Radium-226	Thorium-232
115	450	0-4	b	3.3 + 1.8	75.3 + 3.0
115	450	4-8	b	2.7 + 0.9	14.9 + 1.3
115	450	8-12	b	2.4 + 0.6	4.7 + 0.7
115	450	12-16	b	1.5 + 0.4	1.4 + 0.4
115	450	16-20	b	2.1 + 0.4	0.4 + 0.5
117	440	0-4	b	b	232.1 + 5.6
117	440	4-8	b	1.5 + 0.7	8.5 + 0.9
117	440	8-12	b	1.3 + 0.6	1.9 + 0.4
117	440	12-16	b	1.5 + 0.5	1.0 + 0.5
117	440	16-20	b	2.4 + 0.6	1.0 + 0.3
162	395	0-4	b	4.7 + 1.5	46.3 + 2.5
162	395	4-8	b	1.5 + 0.5	1.8 + 0.4
162	395	8-12	b	0.9 + 0.3	0.6 + 0.4
162	395	12-16	b	1.3 + 0.5	1.0 + 0.4
162	395	16-20	b	0.6 + 0.4	b
190	257	0-4	b	143.6 + 4.2	b
190	257	4-8	5.6 + 3.9	3.4 + 0.7	0.6 + 0.4
190	257	8-12	b	3.2 + 0.5	0.4 + 0.2
190	257	12-16	b	2.3 + 0.6	0.6 + 0.4
190	257	16-20	b	2.4 + 0.7	1.2 + 0.5
190	257	20-24	1.6 + 3.4	1.5 + 0.4	0.5 + 0.2
190	257	24-28	b	1.6 + 0.5	0.9 + 0.4
195	210	0-4	b	34.8 + 2.1	b
195	210	4-8	b	13.3 + 1.2	7.9 + 1.1
195	210	8-12	b	1.1 + 0.3	0.7 + 0.3
195	210	12-16	b	1.2 + 0.5	0.9 + 0.7
195	210	16-20	b	1.7 + 0.6	b
195	210	20-23	b	0.8 + 0.5	b
195	256	0-4	b	2.2 + 0.5	b
195	256	4-6	b	b	3.8 + 1.3
210	300	0-4	b	2.6 + 0.5	1.1 + 0.4
210	300	4-8	b	0.9 + 0.6	1.2 + 0.7
210	300	8-12	b	3.4 + 0.6	3.8 + 0.7
210	300	12-16	b	4.2 + 0.7	2.8 + 0.8
210	300	16-20	b	1.0 + 0.4	0.9 + 0.3
210	300	20-24	b	2.1 + 0.4	0.6 + 0.2
210	300	24-26	b	2.0 + 0.4	1.0 + 0.5
225	180	0-4	b	4.2 + 0.6	2.2 + 0.5
225	180	4-8	b	1.5 + 0.5	2.3 + 0.6
225	180	8-12	b	2.1 + 0.5	1.9 + 0.4
225	180	12-16	34.8 + 14.7	82.3 + 3.0	82.0 + 3.0
225	180	16-20	7.2 + 6.0	2.9 + 0.7	b
229	357	0-4	b	1.5 + 2.0	74.0 + 3.2

TABLE 4-5
(continued)

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Sampling Location		Depth (inches)	Radionuclide Concentrations (pCi/g +/- 2 Sigma)		
Grid E	Grid N		Uranium-238	Radium-226	Thorium-232
229	357	4-8	b	6.9 + 0.9	1.4 + 0.4
229	357	8-12	b	1.6 + 0.5	1.5 + 0.4
229	357	12-16	b	1.4 + 0.5	0.7 + 0.2
229	357	16-20	b	1.2 + 0.4	1.8 + 0.4
229	357	20-24	5.9 + 5.9	2.2 + 1.0	b
259	352	0-4	b	1.7 + 2.2	229.2 + 5.0
259	352	4-8	5.4 + 4.1	1.4 + 0.5	3.4 + 0.8
259	352	8-12	b	1.3 + 0.4	b
267	512	0-4	15.6 + 12.7	2.7 + 1.2	38.6 + 2.2
267	512	4-8	b	1.4 + 0.6	2.9 + 0.6
267	512	8-12	b	1.8 + 0.4	1.6 + 0.6
267	512	12-16	5.9 + 3.4	1.8 + 0.5	1.7 + 0.5
267	512	16-20	b	1.2 + 0.4	1.4 + 0.4
280	532	0-4	b	b	16.3 + 1.4
280	532	4-8	b	b	75.8 + 2.9
280	532	8-12	b	0.8 + 0.3	0.9 + 0.4
280	532	12-16	b	1.0 + 0.5	b
280	532	16-20	b	0.5 + 0.4	0.7 + 0.4
280	532	20-24	b	1.6 + 0.4	1.0 + 0.4

^aSampling locations are shown in Figure 3-4.

^bConcentrations below the minimum detectable activity (MDA) are dependent on many variables (e.g., sample size, moisture content, other nuclide peaks present, etc.). Based on standard counting techniques, the MDA's are: uranium-238, less than 1.0 pCi/g; radium-226, less than 0.4 pCi/g; and thorium-232, less than 0.2 pCi/g.

TABLE 4-6

ALBANY RESEARCH CENTER: GAMMA SPECTROMETRY ANALYSIS OF SEDIMENT SAMPLES^a

Sampling Location	Depth (inches)	Radionuclide Concentrations (pCi/g +/- 2 Sigma)				Comments		
		Uranium-238	Radium-226		Thorium-232			
<u>Grid E</u>	<u>Grid N</u>							
42	218	b	1.3 + 0.8			Inside the drain		
124	407	789.5 + 37.6	3.8	1.5	33.9	2.4	Sump S. of Bldg. 4	
127	426	9.2	8.5	44.7	2.1	5.0	1.0	Acid rinse drain N. of Bldg. 4
156	293	b	2.2	0.7	1.3	0.7	West valve box N. of Bldg. 34	
157	304	b	3.1	0.8	1.0	0.4	Valve box south of Bldg. 17	
160	305	b	2.0	0.5			Valve box south of Bldg. 17	
185.5	167.5	b	2.6	0.6	1.5	0.7	Inside main trunk line drain pipe	
215	290	b	1.3	0.6			Man hole north of Bldg. 35	
Bldg. 17 Sumps		b	9.0	1.0	0.8	0.2	Composite sample of three sumps	
<u>Off-Site</u>								
1	0-6	b	1.1 + 0.9		b		Ditch east of Broadway	
2	0-6	b	b		b		Ditch east of Broadway	
3	0-6	b	2.1 + 1.4		2.9	+ 1.0	Ditch east of Broadway	
4	0-6	b	2.4 + 0.7		3.3	+ 0.8	Ditch east of Broadway	
5	0-6	b	1.3 + 0.4		1.1	+ 0.8	Ditch east of Broadway	
6	0-6	b	b		2.9	+ 0.9	Ditch east of Broadway	
7	0-6	b	0.9 + 0.5		b		Ditch east of Broadway	
8	0-6	b	1.4 + 0.4		1.2	+ 0.7	Morgan pasture	
9	0-6	b	1.4 + 0.4		0.4	+ 0.1	Queen Avenue outfall	

^aSampling locations are shown in Figure 3-8.

^bConcentrations below the minimum detectable activity (MDA) are dependent on many variables (e.g., sample size, moisture content, other nuclide peaks present, etc.). Based on standard counting techniques, the MDA's are: uranium-238, less than 1.0 pCi/g; radium-226, less than 0.4 pCi/g; and thorium-232, less than 0.2 pCi/g.

TABLE 4-7
ALBANY RESEARCH CENTER: SUMMARY OF PRE-REMEDIAL ACTION
WATER SAMPLE ANALYSIS RESULTS^a

Page 1 of 4

Sample Location and Sample Type	Analysis	No. of Samples Analyzed	Concentration Range (pCi/l)	Average (pCi/l)	Criterion (pCi/l)
<u>On-Site Surface Water</u>	Suspended Th-232	14	<0.3 - 22.0	4.5	40,000
	Dissolved Th-232	15	<0.1 - 1.5	0.3	2,000
	Suspended Ra-226	15	<0.1 - 19.0	1.8	30,000
	Dissolved Ra-226	15	<0.1 - 0.4	<0.1	30
	Suspended Total U	15	<1.5 - 66.1	6.2	40,000
	Dissolved Total U	15	<1.5 - 33.0	3.8	600
Swamp West of Bldg. 34	Suspended Th-232	1	<0.1	<0.1	40,000
	Dissolved Th-232	1	<0.2	<0.2	2,000
	Suspended Ra-226	1	0.2	0.2	30,000
	Dissolved Ra-226	1	0.3	0.3	30
	Suspended Total U	1	<1.5	<1.5	40,000
	Dissolved Total U	1	<1.5	<1.5	600
Ditch South of Waste Dump Area	Suspended Th-232	1	<0.1	<0.1	40,000
	Dissolved Th-232	1	<0.2	<0.2	2,000
	Suspended Ra-226	1	<0.1	<0.1	30,000
	Dissolved Ra-226	1	<0.1	<0.1	30
	Suspended Total U	1	<1.5	<1.5	40,000
	Dissolved Total U	1	6.6	6.6	600
<u>On-Site Subsurface Water (Borehole)</u>	Suspended Th-232	16	<0.2 - 42.4	6.4	40,000
	Dissolved Th-232	56	<0.1 - 1.5	0.1	2,000
	Suspended Ra-226	15	<0.1 - 3.0	0.9	30,000
	Dissolved Ra-226	52	<0.1 - 1.1	0.1	30
	Suspended Total U	16	<0.6 - 3.3	0.6	40,000
	Dissolved Total U	56	<1.5 - 84.8	3.4	600
<u>On-Site Subsurface Water, Tile Drain Area</u>	Suspended Th-232	5	<0.1 - 0.6	<0.3	40,000
	Dissolved Th-232	5	<0.1 - 0.3	<0.2	2,000
	Suspended Ra-226	5	<0.1 - 1.2	0.3	30,000
	Dissolved Ra-226	5	<0.1	<0.1	30
	Suspended Ra-228	5	<6.0 - 12.0	<8.0	30,000
	Dissolved Ra-228	5	<4.0 - 6.0	<5.0	30
	Suspended Total U	5	<1.5	<1.5	40,000
	Dissolved Total U	5	<1.5 - 5.4	2.5	600
	Suspended U-238	5	<0.1 - 1.1	0.3	40,000
	Dissolved U-238	5	0.1 - 4.9	1.8	600
	Suspended U-235	5	<0.1	<0.1	30,000
	Dissolved U-235	5	<0.1 - 0.3	<0.2	4,000
	Suspended U-234	5	<0.1 - 0.9	0.3	30,000
	Dissolved U-234	5	0.2 - 5.2	2.0	4,000

TABLE 4-7
(continued)

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Sample Location and Sample Type	Analysis	No. of Samples Analyzed	Concentration Range (pCi/l)	Average (pCi/l)	Criterion (pCi/l)
<u>Off-Site Surface Water</u>					
Queen Ave. Outfall (Composite Samples)	Suspended Th-232	14	<0.1 - 0.4	0.2	40,000
	Dissolved Th-232	14	<0.1 - 0.4	0.2	2,000
	Suspended Ra-226	14	<0.1 - 0.3	0.2	30,000
	Dissolved Ra-226	14	<0.1 - 0.2	0.2	30
	Suspended Total U	14	<0.1 - 0.1	<0.5	40,000
	Dissolved Total U	14	<1.5	<2.5	600
<u>Off-Site Subsurface Water</u>					
Manhole North of 15th St. on Tekena St.	Suspended Th-232	1	<1.0	<7.0	40,000
	Dissolved Th-232	1	<0.4	<0.4	2,000
	Suspended Ra-226	1	0.2	0.2	30,000
	Dissolved Ra-226	1	<0.2	<0.2	30
	Suspended Ra-228	1	<5.0	<5.0	30,000
	Dissolved Ra-228	1	<3.0	<3.0	30
	Suspended Total U	1	<1.5	<1.5	40,000
	Dissolved Total U	1	<1.5	<1.5	600
	Suspended U-238	1	1.2	<1.2	40,000
	Dissolved U-238	1	<0.4	<0.4	600
	Suspended U-235	1	<0.2	<0.2	30,000
	Dissolved U-235	1	<0.2	<0.2	4,000
	Suspended U-234	1	0.3	0.3	30,000
	Dissolved U-234	1	<0.3	<0.3	4,000
Manhole South of 15th St. on Tekena St.	Suspended Th-232	1	<0.1	<0.1	40,000
	Dissolved Th-232	1	<0.3	<0.3	2,000
	Suspended Ra-226	1	0.2	0.2	30,000
	Dissolved Ra-226	1	<0.2	<0.2	30
	Suspended Ra-228	1	<5.0	<5.0	30,000
	Dissolved Ra-228	1	<3.0	<3.0	30
	Suspended Total U	1	<1.5	<1.5	40,000
	Dissolved Total U	1	<1.5	<1.5	600
	Suspended U-238	1	<0.3	0.3	40,000
	Dissolved U-238	1	<0.3	<0.3	600
	Suspended U-235	1	<0.1	<0.1	30,000
	Dissolved U-235	1	<0.1	<0.1	4,000
	Suspended U-234	1	<0.1	<0.1	30,000
	Dissolved U-234	1	<0.3	<0.3	4,000

TABLE 4-7
(continued)

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Sample Location and Sample Type	Analysis	No. of Samples Analyzed	Concentration Range (pCi/l)	Average (pCi/l)	Criterion (pCi/l)
<u>Off-Site Subsurface Water</u> (continued)					
Queen Avenue Manhole (Site Grid O)	Suspended Th-232	1	0.1	0.1	40,000
	Dissolved Th-232	1	<0.3	<0.3	2,000
	Suspended Ra-226	1	<0.1	<0.1	30,000
	Dissolved Ra-226	1	0.2	0.2	30
	Suspended Ra-228	1	<7.0	<7.0	30,000
	Dissolved Ra-228	1	<2.0	<2.0	30
	Suspended Total U	1	<1.5	<1.5	40,000
	Dissolved Total U	1	<1.5	<1.5	600
	Suspended U-238	1	<0.2	<0.2	30,000
	Dissolved U-238	1	<0.1	<0.1	600
	Suspended U-235	1	<0.1	<0.1	30,000
	Dissolved U-235	1	<0.1	<0.1	4,000
	Suspended U-234	1	0.2	0.2	30,000
	Dissolved U-234	1	<0.1	<0.1	4,000
Queen Avenue Manhole (Site Grid U)	Suspended Th-232	1	<0.2	<0.2	40,000
	Dissolved Th-232	1	<0.2	<0.2	2,000
	Suspended Ra-226	1	0.2	0.2	30,000
	Dissolved Ra-226	1	<0.2	<0.2	30
	Suspended Ra-228	1	<3.0	<3.0	30,000
	Dissolved Ra-228	1	<2.0	<2.0	30
	Suspended Total U	1	<1.5	<1.5	40,000
	Dissolved Total U	1	<1.5	<1.5	600
	Suspended U-238	1	<0.1	<0.1	40,000
	Dissolved U-238	1	<0.1	<0.1	600
	Suspended U-235	1	<0.1	<0.1	30,000
	Dissolved U-235	1	<0.1	<0.1	4,000
	Suspended U-234	1	<0.2	<0.2	30,000
	Dissolved U-234	1	<0.1	<0.1	4,000
Manhole at Queen Avenue and Liberty Street	Suspended Th-232	1	<0.8	<0.8	40,000
	Dissolved Th-232	1	<0.1	<0.1	2,000
	Suspended Ra-226	1	<0.1	<0.1	30,000
	Dissolved Ra-226	1	<0.2	<0.2	30
	Suspended Ra-228	1	<3.0	<3.0	30,000
	Dissolved Ra-228	1	<2.0	<2.0	30
	Suspended Total U	1	<1.5	<1.5	40,000
	Dissolved Total U	1	<1.5	<1.5	600
	Suspended U-238	1	<0.2	<0.2	40,000
	Dissolved U-238	1	<0.1	<0.1	600
	Suspended U-235	1	<0.2	<0.2	30,000
	Dissolved U-235	1	<0.1	<0.1	4,000
	Suspended U-234	1	<0.3	<0.3	30,000
	Dissolved U-234	1	<0.2	<0.2	4,000

TABLE 4-7
(continued)

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Sample Location and Sample Type	Analysis	No. of Samples Analyzed	Concentration Range (pCi/l)	Average (pCi/l)	Criterion (pCi/l)
<u>Off-Site Subsurface Water (continued)</u>					
Culvert At 15th Street	Suspended Th-232	1	<0.1	<0.1	40,000
	Dissolved Th-232	1	<0.1	<0.1	2,000
	Suspended Ra-226	1	<0.1	<0.1	30,000
	Dissolved Ra-226	1	<0.2	<0.2	30
	Suspended Ra-228	1	<5.0	<5.0	30,000
	Dissolved Ra-228	1	<2.0	<2.0	30
	Suspended Total U	1	<1.5	<1.5	40,000
	Dissolved Total U	1	<1.5	<1.5	600
	Suspended U-238	1	<0.1	<0.1	40,000
	Dissolved U-238	1	<0.1	<0.1	600
	Suspended U-235	1	<0.1	<0.1	30,000
	Dissolved U-235	1	<0.1	<0.1	4,000
	Suspended U-234	1	<0.1	<0.1	30,000
	Dissolved U-234	1	<0.1	<0.1	4,000
Culvert At 17th Street	Suspended Th-232	1	<0.2	<0.2	40,000
	Dissolved Th-232	1	<0.2	<0.2	2,000
	Suspended Ra-226	1	<0.1	<0.1	30,000
	Dissolved Ra-226	1	<0.2	<0.2	30
	Suspended Ra-228	1	<5.0	<5.0	30,000
	Dissolved Ra-228	1	<2.0	<2.0	30
	Suspended Total U	1	<1.5	<1.5	40,000
	Dissolved Total U	1	<1.5	<1.5	600
	Suspended U-238	1	<0.4	<0.4	40,000
	Dissolved U-238	1	0.2	0.2	600
	Suspended U-235	1	<0.4	<0.4	30,000
	Dissolved U-235	1	<0.1	<0.1	4,000
	Suspended U-234	1	<0.4	<0.4	30,000
	Dissolved U-234	1	0.2	0.2	4,000

^aWater sample locations are shown in Figures 3-6 and 3-7.

TABLE 4-8
ALBANY RESEARCH CENTER: SUMMARY OF PRE-REMEDIAL ACTION
BUILDING MEASUREMENTS

Page 1 of 6

Interior Measurement Locations	Measurement Type	No. of Readings Taken	Measurement Range	Units	Criterion
<u>Building 1</u>					
Electrical Equipment Room Floor	Beta-gamma dose rates	1	0.03	mrad/h	0.20
	Direct alpha activity on surfaces	1	56	dpm/100 cm ²	1000
<u>Building 4</u>					
Owl Room (First Level) Floor	Beta-gamma dose rates	156	0.02 - 5.54	mrad/h	0.20
	Direct alpha activity on surfaces	156	28 - 5464	dpm/100 cm ²	1000
	Transferable alpha	6	4.4 - 52.8	dpm/100 cm ²	200
	Transferable beta	6	15.4 - 127.6	dpm/100 cm ²	(a)
Walls	Beta-gamma dose rates	107	<0.01 - 0.65	mrad/h	0.20
	Direct alpha activity on surfaces	107	0 - 963	dpm/100 cm ²	1000
	Transferable alpha	36	<2.2 - 259.6	dpm/100 cm ²	200
	Transferable beta	36	<6.6 - 1304.6	dpm/100 cm ²	(a)
Floor/Wall Intersections	Beta-gamma dose rates	39	0.02 - 0.70	mrad/h	0.20
	Direct alpha activity on surfaces	39	37 - 3344	dpm/100 cm ²	1000
	Transferable alpha	16	<2.2 - 269.6	dpm/100 cm ²	200
	Transferable beta	16	6.6 - 987.8	dpm/100 cm ²	(a)
Owl Room (Second Level) Floor	Beta-gamma dose rates	28	0.02 - 0.27	mrad/h	0.20
	Direct alpha activity on surfaces	28	9 - 658	dpm/100 cm ²	1000
	Transferable alpha	7	2.2 - 13.2	dpm/100 cm ²	200
	Transferable beta	7	11.0 - 35.2	dpm/100 cm ²	(a)
Walls	Beta-gamma dose rates	38	0.02 - 0.06	mrad/h	0.20
	Direct alpha activity on surfaces	38	0 - 157	dpm/100 cm ²	1000
	Transferable alpha	10	<2.2 - 8.8	dpm/100 cm ²	200
	Transferable beta	10	<6.6 - 24.2	dpm/100 cm ²	(a)
Floor/Wall Intersections	Transferable alpha	4	<2.2	dpm/100 cm ²	200
	Transferable beta	4	<6.6	dpm/100 cm ²	(a)
Owl Room Miscellaneous Equipment	Beta-gamma dose rates	26	0.01 - 55.8	mrad/h	0.20
	Direct alpha activity on surfaces	26	0 - 10,484	dpm/100 cm ²	1000
	Transferable alpha	36	<2.2 - 849	dpm/100 cm ²	200
	Transferable beta	36	<6.6 - 3247.4	dpm/100 cm ²	(a)
Filter Inlets Exteriors	Beta-gamma dose rates	6	0.01 - 0.51	mrad/h	0.20
	Transferable alpha	4	2 - 6	dpm/100 cm ²	200
	Transferable beta	4	13 - 20	dpm/100 cm ²	(a)
Filter Outlets Exteriors	Beta-gamma dose rates	6	0.01 - 0.06	mrad/h	0.20
	Transferable alpha	4	6	dpm/100 cm ²	200
	Transferable beta	4	11 - 26	dpm/100 cm ²	(a)

TABLE 4-8
(continued)

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Interior Measurement Locations	Measurement Type	No. of Readings Taken	Measurement Range	Units	Criterion
<u>Building 5</u>					
Machine Shop Floor	Beta-gamma dose rates	34	0.01 - 0.27	mrad/h	0.20
	Direct alpha activity on surfaces	34	0 - 1973	dpm/100 cm ²	1000
	Transferable alpha	6	<2.2	dpm/100 cm ²	200
	Transferable beta	6	<6.6	dpm/100 cm ²	(a)
Metal Storage Room Floor	Beta-gamma dose rates	5	0.03 - 0.06	mrad/h	0.20
	Direct alpha activity on surfaces	5	28 - 157	dpm/100 cm ²	1000
<u>Building 17</u>					
Hallway	Beta-gamma dose rates	12	0.02 - 0.07	mrad/h	0.20
	Direct alpha activity on surfaces	12	0 - 102	dpm/100 cm ²	1000
Lab 9	Beta-gamma dose rates	2	0.03 - 0.04	mrad/h	0.20
	Direct alpha activity on surfaces	2	9 - 28	dpm/100 cm ²	1000
Room 10	Beta-gamma dose rates	18	0.03 - 0.21	mrad/h	0.20
	Direct alpha activity on surfaces	18	28 - 1139	dpm/100 cm ²	1000
	Transferable alpha	5	<2.2	dpm/100 cm ²	200
	Transferable beta	5	<6.6 - 6.6	dpm/100 cm ²	(a)
<u>Building 19</u>					
Hood (Interior)	Transferable alpha	1	<2.2	dpm/100 cm ²	200
	Transferable beta	1	6.6	dpm/100 cm ²	(a)
<u>Building 23</u>					
Area Below Hopper No. 4	Transferable alpha	1	2.2	dpm/100 cm ²	200
	Transferable beta	1	<6.6	dpm/100 cm ²	(a)
Old Thorium Lab Doorway	Transferable alpha	1	<2.2	dpm/100 cm ²	200
	Transferable beta	1	<6.6	dpm/100 cm ²	(a)
Area Left of Sump (Basement)	Transferable alpha	1	<2.2	dpm/100 cm ²	200
	Transferable beta	1	<6.6	dpm/100 cm ²	(a)
<u>Building 25</u>					
Furnace Tops	Beta-gamma dose rates	3	0.08 - 0.09	mrad/h	0.20
	Direct alpha activity on surfaces	3	37 - 111	dpm/100 cm ²	1000
	Transferable alpha	3	<2.2	dpm/100 cm ²	200
	Transferable beta	3	<6.6	dpm/100 cm ²	(a)

TABLE 4-8
(continued)

Page 3 of 6

Interior Measurement Locations	Measurement Type	No. of Readings Taken	Measurement Range	Units	Criterion
<u>Building 27</u>					
Room 102, Floor	Beta-gamma dose rates	32	0.08 - 6.77	mrad/h	0.20
	Direct alpha activity on surfaces	32	65 - 3881	dpm/100 cm ²	1000
	Transferable alpha	6	<2.2	dpm/100 cm ²	200
	Transferable beta	6	<6.6	dpm/100 cm ²	(a)
<u>Building 28</u>					
Room 15 (Corridor)	Beta-gamma dose rates	4	0.04 - 0.45	mrad/h	0.20
	Direct alpha activity on surfaces	4	37 - 1186	dpm/100 cm ²	1000
	Transferable alpha	1	<2.2	dpm/100 cm ²	200
	Transferable beta	1	<6.6	dpm/100 cm ²	(a)
<u>Building 29</u>					
Room 101 (Floor)	Beta-gamma dose rates	1	0.01	mrad/h	0.20
Room 102 (Floor)	Beta-gamma dose rates	1	0.01	mrad/h	0.20
Room 103 (Floor)	Beta-gamma dose rates	1	0.01	mrad/h	0.20
Room 104 (Floor)	Beta-gamma dose rates	1	0.02	mrad/h	0.20
Room 104 (Sink Drain)	Beta-gamma dose rates	1	0.01	mrad/h	0.20
Room 105 (Floor)	Beta-gamma dose rates	2	0.01 - 0.02	mrad/h	0.20
Room 105 (Sink Drain)	Beta-gamma dose rates	1	0.01	mrad/h	0.20
Room 106 (Counter Top)	Beta-gamma dose rates	1	0.02	mrad/h	0.20
	Transferable alpha	1	<2.2	dpm/100 cm ²	200
Room 106 (Sink Drain)	Beta-gamma dose rates	1	0.02	mrad/h	0.20
Room 107 (Hood)	Beta-gamma dose rates	3	0.01 - 0.04	mrad/h	0.20
	Transferable alpha	1	<2.2	dpm/100 cm ²	200
Room 107 (Sink Drain)	Beta-gamma dose rates	1	0.01	mrad/h	0.20
Room 107 (Floor)	Beta-gamma dose rates	2	0.01	mrad/h	0.20
	Transferable alpha	1	<2.2	dpm/100 cm ²	200
Room 108 (Floor)	Beta-gamma dose rates	1	0.01	mrad/h	0.20
Room 108 (Floor Drain)	Beta-gamma dose rates	1	0.02	mrad/h	0.20
Room 108 (Sink Drain)	Beta-gamma dose rates	1	0.01	mrad/h	0.20
Room 108 (Counter Top)	Beta-gamma dose rates	1	0.01	mrad/h	0.20
Room 109 (Hood)	Beta-gamma dose rates	2	0.01 - 0.02	mrad/h	0.20
	Transferable alpha	1	<2.2	dpm/100 cm ²	200
Room 109 (Sink Drain)	Beta-gamma dose rates	1	5.96	mrad/h	0.20
	Transferable alpha	1	4.32	dpm/100 cm ²	200
Room 109 (Counter Top)	Beta-gamma dose rates	1	0.01	mrad/h	0.20
Room 110 (Floor)	Beta-gamma dose rates	1	0.01	mrad/h	0.20
	Transferable alpha	1	<2.2	dpm/100 cm ²	200
Room 110 (Hood)	Beta-gamma dose rates	2	0.01	mrad/h	0.20
	Transferable alpha	1	<2.2	dpm/100 cm ²	200

TABLE 4-8
(continued)

Page 4 of 6

Interior Measurement Locations	Measurement Type	No. of Readings Taken	Measurement Range	Units	Criterion
<u>Building 29 (continued)</u>					
Room 110 (Counter Top)	Beta-gamma dose rates	1	0.01	mrad/h	0.20
Room 110 (Tool Chest)	Beta-gamma dose rates	1	0.01	mrad/h	0.20
Room 111 (Floor & Drains)	Beta-gamma dose rates	8	0.01 - 0.42	mrad/h	0.20
	Transferable alpha	1	<2.2	dpm/100 cm ²	200
Room 111 (Counter Top)	Beta-gamma dose rates	1	0.01	mrad/h	0.20
Room 113 (Floor)	Beta-gamma dose rates	1	0.01	mrad/h	0.20
Room 114 (Floor)	Beta-gamma dose rates	1	0.01	mrad/h	0.20
Hallway (Floor)	Beta-gamma dose rates	1	0.01	mrad/h	0.20
<u>Second Level</u>					
Rafters	Beta-gamma dose rates	3	0.01	mrad/h	0.20
Floor	Beta-gamma dose rates	4	0.01	mrad/h	0.20
Filter Casing	Beta-gamma dose rates	1	0.01	mrad/h	0.20
<u>Building 30</u>					
<u>Fabrication Room</u>					
Floor	Beta-gamma dose rates	371	<0.01 - 0.66	mrad/h	0.20
	Direct alpha activity on surfaces	371	0 - 1042	dpm/100 cm ²	1000
	Transferable alpha	102	<2.2 - 11.0	dpm/100 cm ²	200
	Transferable beta	102	<6.6 - 50.6	dpm/100 cm ²	(a)
Walls	Beta-gamma dose rates	134	0.01 - 0.06	mrad/h	0.20
	Direct alpha activity on surfaces	133	0 - 610	dpm/100 cm ²	1000
	Transferable alpha	64	<2.2 - 22	dpm/100 cm ²	200
	Transferable beta	64	<6.6 - 8.8	dpm/100 cm ²	(a)
Floor/Wall Intersections	Beta-gamma dose rates	43	0.01 - 0.06	mrad/h	0.20
	Direct alpha activity on surfaces	43	0 - 204	dpm/100 cm ²	1000
	Transferable alpha	32	<2.2	dpm/100 cm ²	200
	Transferable beta	32	<6.6	dpm/100 cm ²	(a)
<u>Filters</u>					
Inlets	Beta-gamma dose rates	12	0.01 - 6.41	mrad/h	0.20
	Direct alpha activity on surfaces	12	19 - 8984	dpm/100 cm ²	1000
	Transferable alpha	12	<2.2 - 63	dpm/100 cm ²	200
	Transferable beta	12	<6.6 - 244	dpm/100 cm ²	(a)
Outlets	Beta-gamma dose rates	11	0.01 - 0.08	mrad/h	0.20
	Direct alpha activity on surfaces	11	0 - 556	dpm/100 cm ²	1000
	Transferable alpha	11	<2.2 - 11.0	dpm/100 cm ²	200
	Transferable beta	11	<6.6 - 33.0	dpm/100 cm ²	(a)
<u>Overhead Beams</u>					
Overhead Beams	Beta-gamma dose rates	20	0.01 - 0.11	mrad/h	0.20
	Direct alpha activity on surfaces	20	17 - 492	dpm/100 cm ²	1000
	Transferable alpha	10	<2.2 - 11.0	dpm/100 cm ²	200
	Transferable beta	10	<6.6 - 50.6	dpm/100 cm ²	(a)

TABLE 4-8
(continued)

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Interior Measurement Locations	Measurement Type	No. of Readings Taken	Measurement Range	Units	Criterion
Building 30 (continued)					
Miscellaneous Equipment	Beta-gamma dose rates	17	0.01 - 61.2	mrad/h	0.20
	Direct alpha activity on surfaces	17	0 - 39686	dpm/100 cm ²	1000
	Transferable alpha	10	2.2 - 11.0	dpm/100 cm ²	200
	Transferable beta	10	6.6 - 126.9	dpm/100 cm ²	(a)
Tower Base Floors	Beta-gamma dose rates	17	<0.01	mrad/h	0.20
	Direct alpha activity on surfaces	17	0	dpm/100 cm ²	1000
	Transferable alpha	7	<2.2	dpm/100 cm ²	200
	Transferable beta	7	<6.6	dpm/100 cm ²	(a)
Walls	Beta-gamma dose rates	23	0.01 - 0.03	mrad/h	0.20
	Direct alpha activity on surfaces	23	0 - 51	dpm/100 cm ²	1000
	Transferable alpha	2	2.2	dpm/100 cm ²	200
	Transferable beta	2	6.6	dpm/100 cm ²	(a)
Building 31					
Work Shop Floor	Beta-gamma dose rates	19	0.01 - 0.34	mrad/h	0.20
	Direct alpha activity on surfaces	19	0 - 111	dpm/100 cm ²	1000
	Transferable alpha	1	<2.2	dpm/100 cm ²	200
	Transferable beta	1	<6.6	dpm/100 cm ²	(a)
Walls	Beta-gamma dose rates	28	0.01 - 0.04	mrad/h	0.20
	Direct alpha activity on surfaces	28	0 - 68	dpm/100 cm ²	1000
	Transferable alpha	6	<2.2	dpm/100 cm ²	200
	Transferable beta	6	<6.6 - 6.6	dpm/100 cm ²	(a)
Floor/Wall Intersections	Beta-gamma dose rates	23	0.01 - 0.10	mrad/h	0.20
	Direct alpha activity on surfaces	23	19 - 241	dpm/100 cm ²	1000
	Transferable alpha	2	<2.2	dpm/100 cm ²	200
	Transferable beta	2	<6.6 - 6.6	dpm/100 cm ²	(a)
Filters (Inlets and Outlets)	Beta-gamma dose rates	3	0.02 - 7.57	mrad/h	0.20
	Direct alpha activity on surfaces	3	37 - 7206	dpm/100 cm ²	1000
	Transferable alpha	3	<2.2 - 11.0	dpm/100 cm ²	200
	Transferable beta	3	<6.6 - 17.6	dpm/100 cm ²	(a)
Beams	Beta-gamma dose rates	6	0.01 - 0.03	mrad/h	0.20
	Direct alpha activity on surfaces	6	17 - 136	dpm/100 cm ²	1000
Mechanical Testing Lab Floor	Beta-gamma dose rates	1	0.03	mrad/h	0.20
	Direct alpha activity on surfaces	1	56	dpm/100 cm ²	1000

TABLE 4-8
(continued)

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Interior Measurement Locations	Measurement Type	No. of Readings Taken	Measurement Range	Units	Criterion
<u>Building 31</u> (continued)					
Drain Ends	Transferable alpha	1	<2.2 - 4.4	dpm/100 cm ²	200
	Transferable beta	1	<6.6 - 99.0	dpm/100 cm ²	(a)
Room No. 8 Walls	Beta-gamma dose rates	12	<0.01 - 0.03	mrad/h	0.20
	Direct alpha activity on surfaces	12	0 - 51	dpm/100 cm ²	1000
Room No. 13 Floors	Beta-gamma dose rates	4	0.02 - 0.03	mrad/h	0.20
	Direct alpha activity on surfaces	4	0 - 93	dpm/100 cm ²	1000
Drain	Transferable alpha	1	<2.2	dpm/100 cm ²	200
	Transferable beta	1	<6.6	dpm/100 cm ²	(a)
Room No. 14 Hood	Transferable alpha	1	50.6	dpm/100 cm ²	200
	Transferable beta	1	99.0	dpm/100 cm ²	(a)

^aNo DOE guideline has been established for transferable beta contamination. Data are reported for completeness.

5.0 SIGNIFICANCE OF FINDINGS

5.1 FIELD SURVEY

The survey of field areas of the ARC site revealed areas of elevated concentrations of thorium-232 and radium-226 in surface and subsurface soils. Thorium and radium were found to be the major contaminants on the site. The extent of surface contamination was determined using results from surface soil samples and near-surface gamma measurements. Depths of contamination were determined using logs of borehole gamma readings and the results of subsurface soil samples.

For thorium-232 and radium-226, the extent of contamination was based on the DOE guideline of 5 pCi/g averaged over the first 15 cm of soil below the surface, and 15 pCi/g when averaged over 15-cm thick soil layers more than 15 cm below the surface.

The results of the calculation of the extent of contamination is illustrated in Figure 5-1. These specific areas correspond with the general elevated areas of contamination reported earlier by ANL (Refs. 1 and 2). Calculating the surface area and depth, an estimated 2000 m³ (2600 yd³) of contaminated material will have to be removed for the ARC site to comply with guidelines. Prior estimates by ANL were based upon readings above-background, which resulted in an estimate of 13,500 m³ (17,000 yd³).

In addition, sediments showing above-guideline contamination will have to be removed from exterior sumps located south of Building 4 and Building 17 and an acid drain located north of Building 4 (see Figure 4-4). The amount of material in these sumps and drain is estimated to be approximately 5 m³ (6.5 yd³).

All surface and subsurface water samples both on-site and off-site were below DOE criteria for all radionuclides. Also,

soil samples collected to assess possible non-radiological contaminants were below EPA standards for priority pollutants.

5.2 BUILDING SURVEYS

Results of the building surveys showed above-guideline contamination that falls into three categories: surface contamination of portions of the buildings, floors and/or walls; contamination in trenches and drains; and contamination of equipment.

Table 5-1 lists each building in which above-guideline contamination was located. As applicable, Table 5-1 gives the area of surface contamination and the other contamination (e.g., trenches, equipment) in each building.

As shown in Table 5-1, the total surface area to be decontaminated (not including the floor/wall intersections in Building 4) equals 45 m^2 (484 ft^2). Assuming that surface decontamination would require the removal of 2.5 cm of material from these 45 m^2 (484 ft^2), the total building surface contamination to be removed is approximately 1 m^3 (1.3 yd^3).

The total volume of material likely to result from decontamination of the other contaminated areas and/or equipment listed in the table is estimated to be a minimal amount. Because some of the contaminated equipment will be decontaminated, while other equipment will be removed, the total volume of material will be determined during remedial action.

TABLE 5-1
 SUMMARY OF ABOVE-CRITERIA CONTAMINATION IN BUILDINGS
 ALBANY RESEARCH CENTER

Building	Contaminated Surface Area	Other Contamination
4 - Level 1	11 m ²	6 floor/wall intersections; 5 pieces of equipment 2 filter outlets
4 - Level 2	2 m ²	---
5	3 m ²	---
17	2 m ²	---
23	---	3 trenches with contaminated sediments
27	20 m ²	---
28	1 m ²	---
29	---	2 drains
30	4 m ²	Tube furnace and pump
31	2 m ²	---
30, 31	---	Contaminated filter system; 9 inlets above guidelines
TOTAL	45 m ²	---

REFERENCES

1. Argonne National Laboratory (ANL). Radiological Survey of the Albany Metallurgical Research Center, United States Bureau of Mines BioMass Facility and the "Back Forty" Area, Albany, Oregon, DOE/EV-0005/39, ANL-OHS/HP-83-101, prepared for U.S. Department of Energy by ANL, Argonne, IL, April 1983.
2. ANL. Formerly Utilized MED/AEC Sites Remedial Action Program Radiological Survey of the Albany Metallurgical Research Center, United States Bureau of Mines, Albany, Oregon, DOE/EV-0005/40, ANL-OHS/HP-83-102, Argonne, IL, August 1983.
3. A. H. Environment, Inc. A Comprehensive Radiation Survey Report, prepared for the U.S. Bureau of Mines, contract number S0221017, Albany, Oregon, December 1981.
4. Oak Ridge National Laboratory. Results of State Background Radiation Levels: Measurements Taken During 1975-1979, ORNL/TM-7343, Oak Ridge, TN, November 1981.
5. U.S. Department of Energy. "Environmental Protection, Safety, and Health Protection Program for DOE Operations," DOE Order 5480.1A, Washington, DC.
6. U.S. Department of Energy. Interim Residual Contamination and Waste-Control Guidelines for Formerly Utilized Sites Remedial Action Program (FUSRAP) and Remote Surplus Facilities Management Program (SFMP) Sites, (Draft), September 1984.
7. Letter, Environmental Analysis Laboratory Corporation to Eberline Instrument Corporation, "Analysis Report," EAL W.O. No. 455300-1777-44, Richmond, CA, June 22, 1984.